DIVISION 6 STRUCTURES

SECTION 6-01 GENERAL REQUIREMENTS - STRUCTURES

6-01.1 DESCRIPTION

Section 6-01 relates to structural, and incidental items used in any or all types of existing or proposed Structures. The provisions of Section 6-01 supplement the detailed Specifications provided for any given Structure unless specified otherwise in the Contract.

6-01.2 FOUNDATION DATA

See Section 1-02.4(2) for subsurface information.

6-01.3 CLEARING THE SITE

The Contractor shall clear the entire site for the proposed structure to the limits staked by the Engineer.

6-01.4 APPEARANCE OF STRUCTURES

To achieve a more pleasing appearance, the Engineer may require the Contractor to make minor adjustments to the height and alignment of bridge railings, traffic barrier, and structural curbs.

6-01.5 RESERVED

6-01.6 LOAD RESTRICTIONS ON BRIDGES UNDER CONSTRUCTION

Bridges under construction shall remain closed to all traffic, including construction equipment, until the substructure and the superstructure, through the roadway deck, are complete for the entire Structure, except as provided herein. Completion includes release of all falsework, removal of all forms, and attainment of the minimum design concrete strength and specified age of the concrete in accordance with these Specifications. Construction traffic shall not occupy the Structure until the Engineer allows. Once the Structure is complete and is accepted by the Engineer, Section 1-07.7 shall govern all traffic loading, including all construction loading.

If necessary and safe to do so, and if the Contractor requests it in writing, the Engineer may allow traffic on a bridge prior to completion. However, the Contractor shall first submit the following information:

1. Describe the extent of the Structure completion at time of the proposed equipment loading.
2. Describe the loading arrangement, movement, and position of traffic (equipment) on the bridge.
3. Provide stress calculations prepared by (or under the direction of) a professional engineer, licensed under Title 18 RCW, State of Washington, and carrying the professional engineer's signature and seal in accordance with Section 1-05.3(12), and
4. State that the Contractor assumes all risk for damage.

6-01.7 NAVIGABLE STREAMS

The Contractor shall keep navigable streams clear so that water traffic may pass safely, providing and maintaining all lights and signals required by the U.S. Coast Guard. The Contractor shall also comply with all channel depth and clearance line requirements of the U.S. Corps of Engineers. This may require removing material deposited in the channel during construction.

6-01.8 RESERVED

6-01.9 SHOP DRAWINGS

Shop Drawing requirements shall comply with Section 1-05.3 with the following exceptions:

The Shop Drawings and calculations shall be provided far enough in advance of actual need to allow for the review process by the Engineer or other agencies, which may result in no exception taken, make correction noted, rejection, revision and re-submittal, or submit specified item. The Engineer will require up to 30 days for review from the date the submittals are received by the Engineer until they are sent to the Contractor. This time period may increase if the Shop Drawings submitted either do not meet the Contract requirements, or do not contain sufficient detail.

Unless designated otherwise by the Contractor, submittals of Shop Drawings will be reviewed in the order they are received by the Engineer. In the event that several sets of Shop Drawings are submitted simultaneously, the Contractor shall designate the sequence in which these Shop Drawings are to be reviewed. If the Contractor does not submit a Shop Drawing designated review sequence for simultaneous Shop Drawing submittals, the review sequence shall be at the Engineer's discretion.

Shop Drawings and calculations shall be prepared by (or under the direction of) a professional engineer, licensed under Title 18 RCW, State of Washington, and shall carry the professional engineer's signature and seal, in accordance with Section 1-05.3(12).

6-01.10 RESERVED

6-01.11 NAME PLATES

The Contractor shall install no permanent plates or markers on a Structure unless the Contract designates it.

6-01.12 STRUCTURE CLEANUP

Roadside and final cleanup shall be as specified in Section 1-04.11.

6-01.13 ARCHITECTURAL FEATURES

Each Material incorporated in the Work shall be uniform in texture and color for consistency in appearance, unless otherwise indicated in the Contract.

To ensure uniform texture and color, the Contractor shall obtain all cement for the Structure from the same manufacturing plant unless the Engineer waives this requirement in writing.

6-01.14 PREMOLDED JOINT FILLER

When the Contract calls for premolded joint filler, the Contractor shall fasten it with galvanized wire nails to one side of the joint. The nails shall be spaced no more than 6 inches apart and shall be 1-1/2 inches from the edges over the entire joint area. The nails shall be at least 1-1/2 inches longer than the thickness of the filler.

The Contractor may substitute for the nails any adhesive by submitting adhesive catalog cuts, and a Manufacturer's Certificate of Compliance stating 1) - the adhesive is compatible with Resilient Bituminous Preformed Expansion Joint Filler meeting the requirements of ASTM D1751 or AASHTO M 213, and 2) be Capable of bonding the filler to Portland cement concrete.

6-01.15 NORMAL TEMPERATURE

Bridge Drawings state horizontal and vertical dimensions at a normal temperature of 64 °F.

6-01.16 MAINTENANCE OF BRIDGE DRAINS

The Contractor shall keep existing and new bridge drains open and functioning during construction. Before bridge drain work begins, the Contractor shall verify existing drains are clear and free flowing, and if not, the Contractor shall immediately notify the Engineer. Maintenance includes keeping drains clean, free of debris, and free flowing. Before acceptance of the bridge drains, the existing and new bridge drains shall be tested for drainage, and clogged or non-flowing drains shall be cleaned and cleared to a free-flowing state acceptable to the Engineer.

SECTION 6-02 CONCRETE STRUCTURES

6-02.1 DESCRIPTION

Section 6-02 applies to the construction of all roadway Structures and their parts made of Portland cement concrete with or without reinforcement. Any part of a Structure to be made of other than Portland cement concrete shall be built as required in the Standard Specifications other than Section 6-02.

6-02.1A DEFINITION

For purposes of Section 6-02, Roadway Structures shall mean bridges and retaining walls and their parts with or without reinforcing steel.

6-02.2 MATERIALS

Materials shall meet the requirements of the following Sections:

Portland Cement and Pozzolans	9-01
Aggregates for Portland Cement Concrete and Gravel Backfill	9-03
Joint and Crack Sealing Materials	9-04
Reinforcing Steel, and Epoxy-Coated Reinforcing Steel	9-07
Paints	9-08
Prestressed Concrete Girders	9-19
Concrete Curing Materials, Pozzolans, and Admixtures	9-23
Plastic Waterstop	9-24
Water	9-25
Elastomeric Bearing Pads	9-35

Bridge drains shall comply with Section 6-02.3(36). Downspouts shall comply with Section 6-02.3(29).

6-02.3 CONSTRUCTION REQUIREMENTS

6-02.3(1) CLASSIFICATION OF STRUCTURAL CONCRETE

The class and designation of concrete to be used shall be as specified in the Contract.

Concrete class: The numerical class of concrete defines the specified minimum compressive strength at 28 days in accordance with ASTM C 39.

Concrete designation: The letter designation following the class of concrete identifies the specific use as follows:

Letter Designation	Designated Concrete Application
P	Piling
W	Underwater
D	Deck

As an example, concrete class 6000D is concrete designated for decks that require a 28 day compressive strength of at least 6,000 psi.

The Contractor may request, by written notice, permission to use a higher class of concrete or different concrete designation. The Contractor may also request the use of different aggregate gradations, use of one or more pozzolans as a substitution in the total cementitious material, use of additional admixtures, and other reasonable changes in the mix design. Such requests will be evaluated for acceptance based on the specified class of concrete, the specified concrete designation, possible change in concrete designation as it applies to the specified application, the accommodating of concrete placement, or other benefits or improvements. Such request shall include the reasons for such change including the benefits in performance of the concrete for that intended application, benefits to concrete placement, any test or performance data demonstrating the change in mix design as beneficial, and other information as applicable. The Engineer will respond in writing within 10 Working Days of receiving such request. The Contractor shall bear any added costs that result from the Engineer's accepting such change. Any such request shall be considered a submittal in accordance with Section 1-05.3.

6-02.3(2) PROPORTIONING MATERIALS

6-02.3(2)A GENERAL

The total water soluble Chloride ion (Cl-) content of the mixed concrete shall not exceed 0.06 percent by weight of cementitious material for prestressed concrete nor 0.10 percent by weight of cementitious material for reinforced concrete. An initial evaluation may be obtained by testing individual concrete ingredients for:

1) total chloride ion content per AASHTO T 260 and totaling these to determine the total water soluble Chloride ion (Cl-), or
2) the total water soluble Chloride ion (Cl-) in accordance with ASTM C 1218.

Unless otherwise specified, the Contractor shall use Type II Portland cement in all concrete as defined in Section 9-01.2(1).

The use of fly ash is required for Class 4000D and 4000P concrete. The use of fly ash and ground granulated blast furnace slag is optional for all other classes of concrete, except ground granulated blast furnace slag will not be allowed in decks.

Fly ash, if used, shall conform to Section 9-01.6(1). Ground granulated blast furnace slag shall conform to Section 9-01.6(2). When pozzolans are included in the concrete mix, the total weight of both these materials shall be as specified in Section 9-23.9.

The water/cement ratio shall be calculated on the total weight of cementitious material. The following are considered cementitious materials: Portland cement, fly ash, ground granulated blast furnace slag and microsilica.

As an alternative to the use of fly ash, ground granulated blast furnace slag and cement as separate components, a blended hydraulic cement that meets the requirements of Section 9-01.2(4) Blended Hydraulic Cements may be used.

6-02.3(2)B CONTRACTOR MIX DESIGN

The Contractor shall provide a mix design for all classes and designations of concrete specified in the Contract. No concrete shall be placed until the Engineer has approved the mix design. The required average 28 day compressive strength shall be selected per ACI 318, chapter 5, Section 5.3.2. ACI 211.1 and ACI 318 shall be used to determine proportions. The proposed mix for Class 4000P shall provide a minimum fly ash content per cubic yard of 100 pounds and a minimum cement content per cubic yard of 600 pounds. The proposed mix for Class 4000D shall provide a minimum fly ash content per cubic yard of 75 pounds and a minimum cement content per cubic yard of 660 pounds. All other concrete mix designs, except those for lean concrete and commercial concrete, shall have a minimum cementitious material content of 564 pounds per cubic yard of concrete.

The Contractor shall submit a mix design to the Engineer for approval and shall provide a unique identification for each mix design and shall include the mix proportions per cubic yard, the proposed sources, the average 28 day compressive strength for which the mix is designed, the fineness modulus, water cement ratio, and the aggregate correction factor per ASTM C 231. Concrete placeability, workability, and strength shall be the responsibility of the Contractor. The Contractor shall notify the Engineer by written notice of any mix design modifications at least 10 Working Days in advance.

Fine aggregate shall conform to Section 9-03.1(2) Class 1 or Class 2.

Coarse aggregate shall conform to Section 9-03.1(3). The nominal maximum size aggregate for Class 4000P shall be 1/2 inch. The nominal maximum size aggregate for Class 4000D shall be 3/4 inch.

Nominal maximum size for concrete aggregate is defined as the smallest standard sieve opening through which the entire amount of the aggregate is permitted to pass.

Class 4000D and 4000P concrete shall include a water reducing admixture in the amount recommended by the manufacturer. A retarding admixture is required in concrete Class 4000P. Water reducing and retarding admixtures are optional for all other concrete classes.

Air content shall be no less than 5.0 percent and no greater than 7.0 percent for all concrete placed above the finished ground line.

A high-range water reducer (superplasticizer) may be used in all mix designs. Microsilica fume may be used in all mix designs. The use of a high-range water reducer or microsilica fume shall be submitted as a part of the Contractor's concrete mix design.

6-02.3(3) READY MIX CONCRETE

6-02.3(3)A GENERAL

All concrete for roadway structures shall be batched in a prequalified manual, semi-automatic, or automatic plant with certification maintained current within a time period not exceeding two (2) years by the National Ready Mix Concrete Association (NRMCA). Information concerning NRMCA certification may be obtained from the National Ready Mix Concrete Association at 900 Spring Street, Silver Springs, MD 20910. The Engineer is not responsible for any delays to the Contractor due to problems in getting the plant certified.

6-02.3(3)B RESERVED

6-02.3(3)C JOB SITE MIXING

For small quantities of concrete, the Contractor may mix concrete at the Project Site provided the Contractor has in advance provided written notice requested in writing and received written permission from the Engineer. The Contractor's written notice shall include a mix design, batching and mixing procedures, and a list of the equipment performing the mixing at the Project Site. All Project Site mixed concrete shall be mixed in a mechanical mixer.

If the Engineer permits, hand mixing of concrete will be permitted for pipe collars, pipe plugs, fence posts, or other items as approved by the Engineer, provided the hand mixing is done on a watertight platform in a way that distributes materials evenly throughout the mix. Mixing shall continue long enough to produce a homogeneous mixture. No Project Site mixed batch shall exceed one-half (1/2) cubic yard.

Concrete mixed at the Project Site shall never be placed in water.

6-02.3(3)D CONSISTENCY

The maximum slump for vibrated concrete shall be:

1. 3.5 inches for vibrated concrete placed in all bridge roadway slabs, bridge approach slabs, and flat slab bridge superstructures.
2. 4.5 inches for all other vibrated concrete.

The maximum slump for non-vibrated concrete shall be 7 inches including Classes 4000P and 4000W.

6-02.3(3)E TEMPERATURE AND TIME FOR PLACEMENT

Concrete temperatures shall remain between 55ºF and 90ºF while it is being placed. Precast concrete that is heat cured per Section 6-02.3(25)E shall remain between 50ºF and 90ºF while being placed. The batch of concrete shall be discharged at the Project Site no more than 90 minutes (1-1/2 hours) after the cementitious material is added to the concrete mixture. The time to discharge may be extended to 105 minutes (1-3/4 hours) if the temperature of the concrete being placed is less than 75ºF.

6-02.3(4) ACCEPTANCE OF CONCRETE

6-02.3(4)A GENERAL

All concrete for roadway Structures will be accepted based on conformance to the requirement for temperature, slump, air content for concrete placed above finished ground line, and the specified compressive strength at 28 days for sublots as tested and determined by the Engineer. For non-roadway Structure concrete, acceptance by the Engineer will be by Manufacturer's Certificate of Compliance unless the Contract specifies otherwise.

A sublot is defined as the material represented by an individual strength test. An individual strength test is the average compressive strength of cylinders from the same sample of material.

Each sublot will be deemed to have met the specified compressive strength requirement when both of the following conditions are met:

1. Individual strength tests do not fall below the specified strength by more than 12-1/2 % or 500 psi, whichever is least, and
2. An individual strength test averaged with the two preceding individual strength tests meets or exceeds specified strength (for the same class and exact mix I.D. of concrete on the same Contract).

When compressive strengths fail to satisfy one or both of the above requirements, the Contractor may:

Request acceptance of in-place concrete strength based on core results. This method will not be used if the Engineer determines coring would be harmful to the integrity of the structure. Cores, if allowed, will be obtained by the Contractor in accordance with ASTM C 42 and delivered to the contracting agency for testing in accordance with ASTM C 39. If the concrete in the structure will be dry under service conditions, the core will be air dried at a temperature of between 60ºF and 80ºF and at a relative humidity of less than 60 percent for seven days before testing, and will be tested air dry.

Acceptance for each sublot by the core method requires that the average compressive strength of three cores be at least 85 percent of the specified strength with no one core less than 75 percent of the specified strength. When the Contractor requests strength analysis by coring, the results obtained will be accepted by both parties as conclusive and supersede all other strength data for the concrete sublot.

If the Contractor elects to core, cores shall be obtained no later than 50 days after initial concrete placement. The Engineer will concur in the locations to be cored. Repair of cored areas shall be the responsibility of the Contractor. The cost incurred in coring and testing these cores, including repair of core locations, shall be borne by the Contractor.

6-02.3(4)B MANUFACTURER'S CERTIFICATE OF COMPLIANCE

The concrete producer shall provide a Manufacturer's Certificate of Compliance for each truckload of delivered concrete verifying that the delivered concrete is in compliance with the mix design, and shall include:

1. Manufacturer's plant (batching facility),
2. Owner contract number (PW# found on page 1 of the Agreement Form),
3. Date,
4. Time batched,
5. Truck No.,
6. Initial revolution counter reading,
7. Quantity (quantity batched this load),
8. Type of concrete by class and producer design mix number,
9. Cement producer, type, and Mill Certification No. (The mill test number as required by Section 9-01.3 is the basis for acceptance of cement.),
10. Pozzolan(s) (if used) brand(s) and Type(s),
11. Approved aggregate gradation designation, and
12. Mix design weight per cubic yard and actual batched weights for:
    a. Cement,
    b. Pozzolan including fly ash, slag, microsilica fume (for each type pozzolan if used),
    c. Coarse concrete aggregate and moisture content (each size),
    d. Fine concrete aggregate and moisture content,
    e. Water including free moisture in aggregates), and
    f. Admixture(s) brand and type, and total quantity each in batch.

The Manufacturer's Certificate of Compliance shall be signed by a responsible representative of the concrete Supplier, affirming the accuracy of the information provided.

6-02.3(4)C CONFORMANCE TO MIX DESIGN

Cement, coarse and fine aggregate weights shall be within the following tolerances of the mix design:

Batch Volumes less than or equal to 4 cubic yards	
Component	**Tolerance**
Portland Cement	+5% -1%
Aggregate	+10% -2%

Batch Volumes more than 4 cubic yards	
Component	**Tolerance**
Portland Cement	+5% -1%
Aggregate	+2% -2%

If the total cementitious material weight is made up of different components, these component weights shall be within the following tolerances:

Cementitious Material	Tolerance of that specified in the mix design
Portland cement weight	+5% or -1%
Fly ash weight	±5%
Microsilica weight	±10%
Slag	±5%

Water shall not exceed the maximum water specified in the mix design.

6-02.3(4)D TEST METHODS

Acceptance testing will be performed by the Engineer in accordance with the following:

Test Method	Test Description
AASHTO Test Method T 22 ASTM C 39	Compressive Strength of Cylindrical Concrete Specimens
WSDOT FOP for AASHTO T 23 ASTM C 31	Making and Curing Concrete Test Specimens in the Field
WSDOT FOP for AASHTO Test Method T 119 ASTM C 143	Slump of Hydraulic Cement Concrete
WAQTC FOP for TM 2 ASTM C 172	Sampling Freshly Mixed Concrete
WAQTC FOP for AASHTO T 152 ASTM C 231	Air Content of Freshly Mixed Concrete by the Pressure Method
AASHTO Test Method T 231 ASTM C 617	Capping Cylindrical Concrete Specimens
WSDOT FOP for AASHTO Test Method T 309 ASTM C 1064	Temperature of Freshly Mixed Portland Cement Concrete

6-02.3(4)E POINT OF ACCEPTANCE

Determination of concrete properties for acceptance will be made based on samples taken at the discharge of the placement system.

It shall be the Contractor's responsibility to provide adequate and representative samples of the fresh concrete to a location designated by the Engineer for the testing of concrete properties and making of cylinder specimens. Samples shall be provided as directed in Sections 1-06.1 and 1-06.2. Once the Contractor has turned over the concrete for acceptance testing, no more mix adjustment will be allowed. The concrete will either be accepted or rejected.

6-02.3(4)F WATER/CEMENT RATIO CONFORMANCE

The actual water cement ratio shall be determined from the certified proportions of the mix, adjusting for Project Site additions. No water may be added after acceptance testing or after placement has begun, except for concrete used in slip forming. For slip-formed concrete, water may be added during placement but shall not exceed the maximum water cement ratio in the mix design, and shall meet the requirements for consistency as described in Section 6-02.3(3)D. If water is added, an air and temperature test will be taken prior to resuming placement to ensure that specification conformance has been maintained.

6-02.3(4)G SAMPLING AND TESTING FREQUENCY FOR TEMPERATURE, CONSISTENCY, AND AIR CONTENT

Concrete properties shall be determined from concrete as delivered to the Project Site and as accepted by the Contractor for placement. The Engineer will test for acceptance of concrete for slump, temperature, and air content, if applicable.

Sampling and testing will be performed before concrete placement from the first truck load. Concrete shall not be placed until tests for slump, temperature, and entrained air (if applicable) have been completed by the Engineer, and the results indicate that the concrete is within acceptable limits. Except for the first load of concrete, up to 1/2 cubic yard may be placed prior to testing for acceptance. Sampling and testing will continue for each load until two successive loads meet all applicable acceptance test requirements. After two successive tests indicate that the concrete is within specified limits, the sampling and testing frequency may decrease to one for every five truck loads.

When the results for any subsequent acceptance test indicates that the concrete as delivered and approved by the Contractor for placement does not conform to the specified limits, the sampling and testing frequency will be resumed for each truck load. Whenever two successive subsequent tests indicate that the concrete is within the specified limits, the random sampling and testing frequency of one for every five truck loads may resume.

Sampling and testing for a placement of one class of concrete consisting of 50 cubic yards or less will be as listed above, except:

1. Sampling and testing will continue until one load meets all of the applicable acceptance requirements, and
2. After one set of tests indicate that the concrete is within specified limits, the remaining concrete to be placed may be accepted by visual inspection.

6-02.3(4)H SAMPLING AND TESTING FOR UNIT WEIGHT AND COMPRESSIVE STRENGTH

Acceptance testing for compressive strength will be conducted at the same frequency as specified in Section 6-02.3(4)G.

6-02.3(4)I REJECTING CONCRETE

Rejection Without Testing — The Engineer, prior to sampling, may reject any batch or load of concrete that appears defective in composition; such as cement content or aggregate proportions or slump. Rejected material shall not be incorporated in the Structure.

6-02.3(5) PLACING CONCRETE

6-02.3(5)A DAILY MEETING - BEFORE CONCRETE PLACEMENT

Before placing each days concrete, the Contractor shall arrange for a pre-concrete placement meeting with the Engineer to ensure the Contractor is fully prepared for that day's specific concrete placement process in its entirety.

6-02.3(5)B GENERAL

The Contractor shall not place concrete:

1. On frozen or ice-coated ground or subgrade;
2. Against or on ice-coated forms, reinforcing steel, structural steel, conduits, precast members, or construction joints;
3. Under rainy conditions; placing of concrete shall be stopped before the quantity of surface water is sufficient to affect or damage surface mortar quality or cause a flow or wash the concrete surface;
4. In any foundation until the Engineer has approved its depth and character;
5. In any form until the Engineer has approved it and the placement of any reinforcing in it; or
6. In any work area when vibrations from nearby work may harm the concrete's initial set or strength.

When a foundation excavation contains water, the Contractor shall pump it dry before placing concrete. If this is impossible, an underwater concrete seal shall be placed that complies with Section 6-02.3(5)B. This seal shall be thick enough to resist any uplift.

All foundations and forms shall be moistened with water just before the concrete is placed. Any standing water on the foundation or in the form shall be removed.

The Contractor shall place concrete in the forms as soon as possible after mixing. The concrete shall always be plastic and workable.

Concrete placement shall be continuous, with no interruption longer than 30 minutes between adjoining layers unless the Engineer approves a longer time. Each layer shall be placed and consolidated before the preceding layer takes initial set. After initial set, the forms shall not be jarred, and projecting ends of reinforcing bars shall not be disturbed.

In girders or walls, concrete shall be placed in continuous, horizontal layers 1.5 to 2.5 feet deep. Compaction shall leave no line of separation between layers. In each part of a form, the concrete shall be deposited as near its final position as possible.

Any method for placing and consolidating shall not segregate aggregates or displace reinforcing steel. Any method shall leave a compact, dense, and impervious concrete with smooth faces on exposed surfaces. Plastering is not permitted. Any section of defective concrete shall be removed at the Contractor's expense.

To prevent aggregates from separating, the length of any conveyor belt used to transport concrete shall not exceed 300 feet. If the mix needs protection from sun or rain, the Contractor shall cover the belt. When concrete pumps are used for placement, a Contractor's representative shall, prior to use on the first placement of each day, visually inspect the pumps water chamber for water leakage. No pump shall be used that allows free water to flow past the piston.

If a concrete pump is used as the placing system, the pump priming slurry shall be discarded before placement. Initial acceptance testing may be delayed until the pump priming slurry has been eliminated from the concrete being pumped. Eliminating the priming slurry from the concrete may require that several cubic yards of concrete are discharged through the pumping system and disposed of.

If the concrete will drop more than 5 feet, it shall be deposited through a sheet metal (or other approved) conduit. If the form slopes, the concrete shall be lowered through approved conduit to keep it from sliding down one side of the form. No aluminum conduits or tremies shall be used to pump or place concrete.

Before placing concrete for roadway slabs on steel spans, the Contractor shall release the falsework under the bridge and let the span swing free on its supports. Concrete in flat slab bridges shall be placed in one continuous operation for each span or series of continuous spans.

Concrete for roadway slabs and the stems of T-beams or box-girders shall be placed in separate operations if the beam or girder stem is more than 3 feet deep. First the stem shall be filled to the bottom of the slab fillets. Roadway slab concrete shall not be placed until enough time has passed to permit the earlier concrete to shrink (at least 12 hours). If stem depth is 3 feet or less, the Contractor may place concrete in one continuous operation if the Engineer approves.

Between expansion or construction joints, concrete in beams, girders, roadway slabs, piers, columns, walls, and traffic and pedestrian barriers, etc., shall be placed in a continuous operation.

No traffic or pedestrian barrier shall be placed until after the roadway slabs are complete for the entire structure. No concrete barriers shall be placed until the falsework has been released and the span supports itself. The Contractor may choose not to release the deck overhang falsework prior to the barrier placement. The Contractor shall submit calculations to the Engineer indicating the loads induced into the girder webs due to the barrier weight and any live load placed on the structure do not exceed the design capacity of the girder component. This analysis is not required for bridges with concrete superstructures. No barrier, curb, or sidewalk shall be placed on steel or prestressed concrete girder bridges until the roadway slab reaches a compressive strength of at least 3,000 psi.

The Contractor may construct traffic and pedestrian barriers by the slipform method. However, the barrier may not deviate more than 1/4 inch when measured by a 10-foot straightedge held longitudinally on the front, back, and top surfaces.

6-02.3(5)C WEATHER AND TEMPERATURE LIMITS TO PROTECT CONCRETE

Hot Weather Protection

The Contractor shall provide concrete within the specified temperature limits by:

1. Shading or cooling aggregate stockpiles (sprinkling of fine aggregate stockpiles with water is not allowed). If sprinkling of the coarse aggregates is to be used, the stockpiles moisture content shall be monitored and the mixing water adjusted for the free water in the aggregate. In addition, when removing the coarse aggregate, it shall be removed from at least 1 foot above the bottom of the stockpile.
2. Refrigerating mixing water; or replacing all or part of the mixing water with crushed ice, provided the ice is completely melted by placing time.

If the concrete would probably exceed 90ºF using normal methods, the Engineer may require approved temperature-reduction measures be taken before the placement begins.

If air temperature exceeds 90ºF, the Contractor shall use water spray or other approved methods to cool all concrete-contact surfaces to less than 90ºF. These surfaces include forms, reinforcing steel, steel beam flanges, and any others that touch the concrete mix. The Contractor shall reduce the time between mixing and placing to a minimum and shall not permit mixer trucks to remain in the sun while waiting to discharge concrete. Chutes, conveyors, and pump lines shall be shaded.

If bridge roadway slabs are placed while air temperature exceeds 90ºF, the Contractor shall:

1) Cover the top layer of reinforcing steel with clean, wet burlap immediately before concrete placement;
2) Sprinkle cool water on the forms and reinforcing steel just before the placement if the Engineer requires it;
3) Finish the concrete slab without delay; and
4) Provide at the site water-fogging equipment to be used if needed after finishing to prevent plastic cracks.

If the evaporation rate at the concreting site is 0.20 pounds per square foot of surface per hour or more as determined from table 6-02.3(5)-1, the Contractor shall surround the fresh concrete with an enclosure. This enclosure shall protect the concrete from wind blowing across its surface until the curing compound is applied. If casting deck concrete is 80ºF or hotter, the Contractor shall install approved equipment at the site clearly displaying relative humidity and wind velocity.

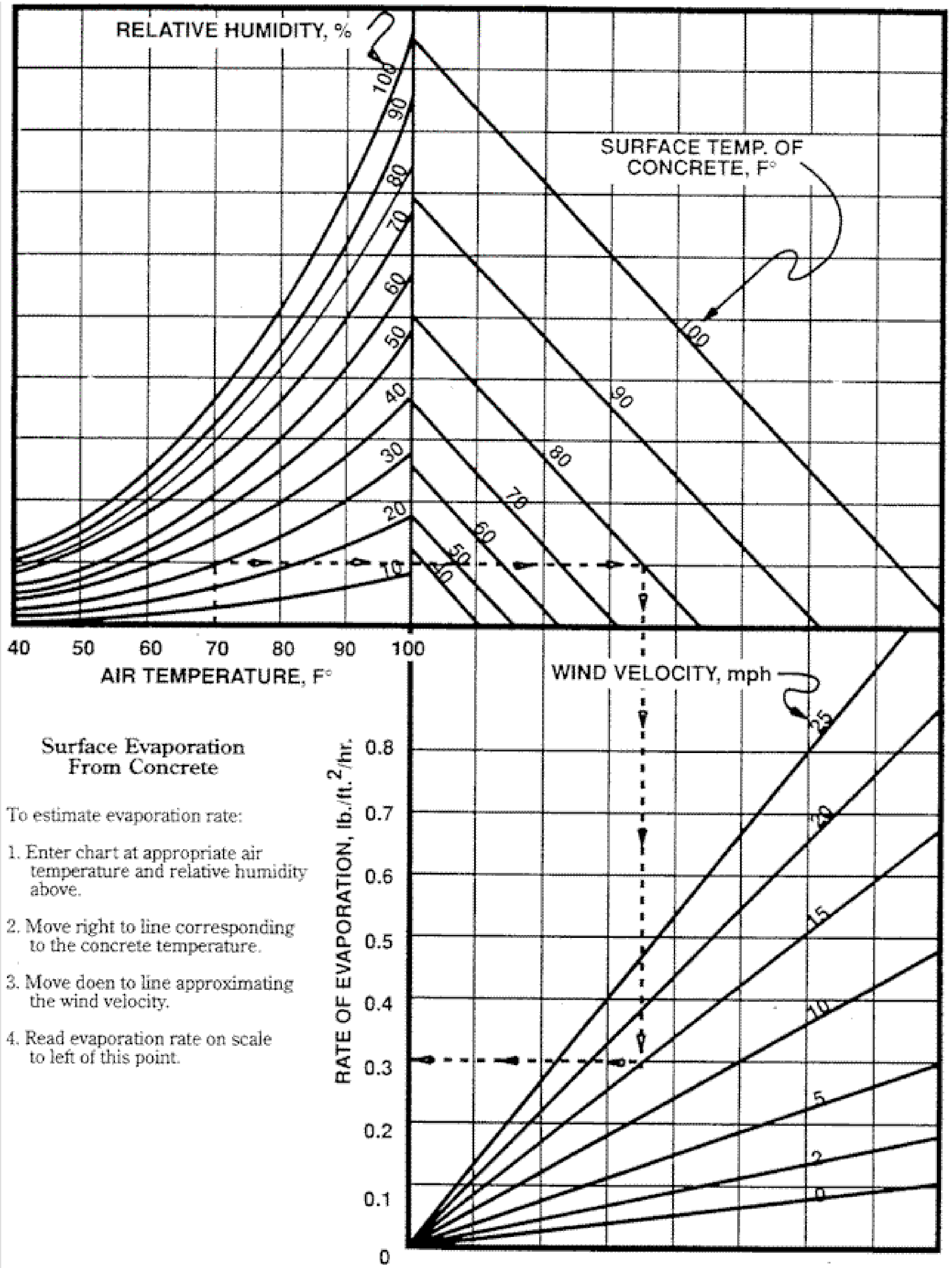

Table 6-02.3(5)-1 Surface Evaporation from Concrete

Cold Weather Protection

The Contractor is solely responsible for protecting concrete from inclement weather during the entire curing period. The Contractor shall provide a written procedure for cold weather concreting to the Engineer for review and approval. The procedure shall detail how the Contractor shall prevent the concrete temperature from falling below 50º F. Extra protection shall be provided for areas especially vulnerable to freezing (such as exposed top surfaces, corners and edges, thin sections, and concrete placed into steel forms). Permission given by the Engineer to place concrete during cold weather will in no way ensure acceptance of the work by the Owner. Should the concrete placed under such conditions prove unsatisfactory in any way, the Engineer shall still have the right to reject the work although the work were carried out with the Engineer's permission.

If weather forecasts predict air temperatures below 35ºF during the seven days just after the concrete placement, the Contractor may place the concrete only if its approved cold weather concreting written procedure is implemented.

The Contractor shall provide and maintain a maturity meter in the concrete at a location specified by the Engineer for each concrete placement. During curing, data from the maturity meter shall be readily available to the Engineer. The Contractor shall record and provide time and temperature data on hourly intervals.

The Contractor shall not mix nor place concrete while the air temperature is below 35ºF, unless the water or aggregates (or both) are heated to at least 70ºF. The aggregate temperature shall not exceed 150ºF. If the water is heated to more than 150ºF, it shall be mixed with the aggregates before the cement is added. Any equipment and methods shall heat the materials evenly. Concrete placed in shafts and piles below the ground surface is exempt from such preheating requirements.

The Contractor may warm stockpiled aggregates with dry heat or steam, but not by applying flame directly or under sheet metal. If the aggregates are in bins, steam or water coils or other heating methods may be used if aggregate quality is not affected. Live steam heating is not permitted on or through aggregates in bins. If using dry heat, the Contractor shall increase mixing time enough to permit the super-dry aggregates to absorb moisture.

Any concrete placed in air temperatures below 35ºF shall be immediately protected. In addition to the monitoring of the concrete temperature with a maturity meter, the Contractor shall provide recording thermometers or other approved devices to monitor the surface temperature of the concrete. The concrete surface temperature shall be maintained at or above 50ºF and the relative humidity shall be maintained above 80 percent. These conditions shall be maintained for a minimum of seven days or for the cure period required by Section 6-02.3(11), whichever is longer. If artificial heat is used to maintain the temperature inside an enclosure, moisture shall be added to the enclosure to maintain the relative humidity as previously stated. The Contractor shall stop adding moisture 24 hours before removing the heat.

If at any period during curing, the concrete temperature falls below 50ºF on the maturity meter or recording thermometer, no curing time is awarded for that day and the required curing time will be extended day for day where the temperature falls below 50ºF. Should the Contractor fail to adequately protect the concrete and the temperature of the concrete falls below 35ºF during curing, the Engineer may reject it.

6-02.3(5)D PLACING CONCRETE IN FOUNDATION SEALS

If the Contract requires a concrete seal, the Contractor shall place the concrete underwater inside a watertight cofferdam, tube, or caisson. Seal concrete shall be placed in a compact mass in still water. It shall remain undisturbed and in still water until fully set. While seal concrete is being deposited, the water elevation inside and outside the cofferdam shall remain equal to prevent any flow through the seal in either direction. The cofferdam shall be vented at the vent elevation shown in the Contract. The thickness of the seal is based upon this vent elevation.

The seal shall be at least 18 inches thick unless the Contract indicates otherwise.

To place seal concrete underwater, the Contractor shall use a concrete pump or tremie. The tremie shall have a hopper at the top that empties into a watertight tube at least 10 inches in diameter. The discharge end of the tube on the tremie or concrete pump shall include a device to seal out water while the tube is first filled with concrete. Tube supports shall permit the discharge end to move freely across the entire work area and to drop rapidly to slow or stop the flow.

One tremie or tube may be used for any "unit" right-angled area up to 324 square feet and with no side dimension greater than 18 feet. One tremie or tube may be used for all other "unit" shaped areas with no inside clear dimension greater than 18 feet. Any shaped area with a "unit" greater than specified in the preceding 2 sentences shall have an additional tube or tremie for each additional "unit".

Throughout the underwater concrete placement operation, the discharge end of the tube shall remain submerged in the concrete and the tube shall always contain enough concrete to prevent water from entering. The concrete placement shall be continuous until the work is completed, resulting in a seamless, uniform seal. If the concreting operation is interrupted, the Engineer may require the Contractor to prove by core drilling or other tests that the seal contains no voids or horizontal joints. If testing reveals voids or joints, the Contractor shall repair them or replace the seal at no expense to the Owner.

Concrete Class 4000W shall be used for seals, and it shall meet the consistency requirements of Section 6-02.3(3)D.

6-02.3(5)E DEWATERING CONCRETE SEALS AND FOUNDATIONS

After a concrete seal is constructed, the Contractor shall pump the water out of the cofferdam and place the rest of the concrete in the dry. This pumping shall not begin until the seal has sufficient strength to withstand the hydrostatic pressure (three days for gravity seals and ten days for seals containing piling or shafts).

If weighted cribs are used to resist hydrostatic pressure at the bottom of the seal, the Contractor shall anchor them to the foundation seal. Any method used (such as dowels or keys) shall transfer the entire weight of the crib to the seal.

Pumping shall be done in a way that ensures concrete not being carried away.

6-02.3(6) CONCRETE EXPOSED TO SEA WATER

If sea water will contact a completed concrete Structure, the Contractor shall:

1. Mix the concrete for at least 2 minutes.
2. Control water content to produce concrete that will be as impermeable as possible.
3. Place concrete in a manner to avoid the formation of rock pockets.
4. Place only clean, rust-free reinforcement bars in the concrete.
5. Coat form surfaces heavily with shellac and any approved form release agent.
6. Leave forms intact for at least 30 days after concrete placement (longer if the Engineer requires) to prevent sea water from contacting the concrete.
7. Leave the surface of concrete just as it comes from the forms.
8. Provide special handling for any concrete piles used in sea water to avoid even slight deformation cracks.

6-02.3(7) CONCRETE EXPOSED TO ALKALINE SOILS OR WATER

Concrete proposed for placement in environments with exposure to alkaline soils or water shall have requirements as specified in the Contract.

6-02.3(8) VIBRATION OF CONCRETE

The Contractor shall supply enough vibrators to consolidate the concrete (except that placed underwater) according to the requirements of this Specification section. Each vibrator shall:

1. Be designed to operate while submerged in the concrete,
2. Vibrate at a rate of at least 7,000 pulses per minute, and
3. Receive the Engineer's approval on its type and method of use.

Immediately after concrete is placed, vibration shall be applied in the fresh batch at the point of deposit. In doing so, the Contractor shall:

1) Space the vibrators evenly, no farther apart than twice the radius of the visible effects of the vibration;
2) Ensure that vibration intensity is great enough to visibly affect a weight of 1 inch slump concrete across a radius of at least 18 inches;
3) Insert the vibrators slowly to a depth that will effectively vibrate the full depth of each layer, penetrating into the previous layer on multilayer pours;
4) Protect partially hardened concrete (i.e., nonplastic, which prevents vibrator penetration when only its own weight is applied) by preventing the vibrator from penetrating it or making direct contact with steel that extends into it;
5) Not allow vibration to continue in one place long enough to form pools of grout;
6) Continue vibration long enough to consolidate the concrete thoroughly, but not so long as to segregate it;
7) Withdraw the vibrators slowly when the process is complete; and
8) Not use vibrators to move concrete from one point to another in the forms.

When vibrating and finishing top surfaces that will be exposed to weather or wear, the Contractor shall not draw water or laitance to the surface. In high lifts, the top layer shall be shallow and made up of a concrete mix as stiff as can be effectively vibrated and finished.

To produce a smooth, dense finish on outside surfaces, the Contractor shall hand tamp the concrete.

6-02.3(9) RESERVED

6-02.3(10) ROADWAY SLABS

6-02.3(10)A GENERAL

A preconcreting conference shall be held 5 to 10 Working Days prior to placing concrete to discuss construction procedures, personnel, and equipment to be used. Those attending shall include:

1. (Representing the Contractor) The superintendent and all foremen in charge of placing steel reinforcing bars, of placing the concrete, and of finishing it; and
2. (Representing the Owner) The Engineer and key inspection Assistants.

If the project includes more than one slab, and if the Contractor's key personnel change between concreting operations, an additional conference shall be held just before each slab is placed.

The Contractor shall not place roadway slabs until the Engineer agrees that:

1) Concrete production and placement rates are high enough to meet placing and finishing deadlines;
2) Finishers with enough experience have been employed; and
3) Adequate finishing tools and equipment are at the site.

The finishing machine shall be self-propelled and be Capable of forward and reverse movement under positive control. The finishing machine shall be equipped with a rotating cylindrical single or double drum screed not exceeding 60 inches in length. The finishing machine shall have the necessary adjustments to produce the required cross-section, line, and grade. Provisions shall be made for the raising and lowering of all screeds under positive control. The upper vertical limit of screed travel shall permit the screed to clear the finished concrete surface. When placing concrete abutting a previously placed slab, the side of the finishing machine adjacent to the existing slab shall be equipped to travel on the existing slab. If performance is not acceptable, the Engineer may reject the equipment, any concrete already placed, or both.

The Contractor may use hand-operated strike-boards only for special conditions and for small areas (less than 10 feet in width and 200 feet in length) only when the Engineer approves. These boards shall be sturdy and able to strike off the width of a full roadway lane without intermediate screeds. Strike-boards, screed rails, and any specially made auxiliary equipment shall receive the Engineer's approval before use. All finishing requirements in these Specifications apply to hand-operated finishing equipment.

Screed rails shall rest on adjustable supports that can be removed with the least possible disturbance to the screeded concrete. The supports shall rest on structural members or on forms rigid enough to resist deflection. Supports shall be removable to at least 2 inches below the finished surface. If possible, the Contractor shall place screeds outside the finishing area. However, if they are placed inside the area, they shall be placed above the finished surface.

Screed rails (with their supports) shall be strong enough and stiff enough to permit the finishing machine to operate effectively on them. All screed rails shall be placed and secured for the full length of the slab before the concreting begins. If the Engineer approves in advance, the Contractor may move rails ahead onto previously set supports while concreting progresses. But such movable rails and their supports shall not change the set elevation of the screed.

On steel truss and girder spans, screed rails and bulkheads may be placed directly on transverse steel floorbeams, with the strike-board moving at right angles to the centerline of the roadway.

Before any concrete is placed, the finishing machine shall be operated over the entire length of the slab to check screed deflection. Concrete placement may begin only if the Engineer gives approval of screed deflection based on this test.

Immediately before placing concrete, the Contractor shall check (and adjust if necessary) all falsework and wedges to minimize settlement and deflection from the added weight of the concrete slab. The Contractor shall also install devices, such as telltales, by which the Engineer can readily measure settlement and deflection.

The Contractor shall schedule the concrete placement so that it can be completely finished during daylight. When the remaining daylight has diminished to limit adequate visibility, finishing is permitted if the Contractor provides adequate lighting and the Engineer approves the adequacy of the lighting.

The placement operation shall cover the full width of the roadway or the full width between construction joints. The Contractor shall locate any construction joint over a beam or web that can support the slab on either side of the joint. The joint shall not occur over a pier unless the Contract permits. Each joint shall be formed vertically and in true alignment. The Contractor shall not release falsework or wedges supporting pours on either side of a joint until each side has aged as these Specifications require.

Placement of concrete for slabs shall comply with Section 6-02.3(5)A. The placement method requires approval by the Engineer. In placing the concrete, the Contractor shall:

(1) Place it (without segregation) against concrete placed earlier, as near as possible to its final position, approximately to grade, and in shallow, closely spaced piles;
(2) Consolidate it around reinforcing steel by using vibrators before strike-off by the finishing machine;
(3) Not use vibrators to move concrete;
(4) Not revibrate any concrete surface area where workers have stopped prior to screeding;
(5) Remove any concrete splashed onto reinforcing steel in adjacent segments before concreting them;
(6) Tamp and strike off the concrete with a template or strikeboard moving slowly forward at an even speed;
(7) Maintain a slight excess of concrete in front of the cutting edge across the entire width of the placement operation;
(8) Make enough passes with the strike-board (without bringing excessive amounts of mortar to the surface) to create a surface that is true and ready for final finish; and
(9) Leave a thin, even film of mortar on the concrete surface after the last pass of the strike-board.

Workers shall complete all post screeding operations without walking on the concrete. This may require work bridges spanning the full width of the slab.

After removing the screed supports, the Contractor shall fill the voids with concrete (not mortar).

The Contractor shall float the concrete surface left by the finishing machine to remove roughness, minor irregularities, and seal the surface of the concrete. Floating shall leave a smooth and even surface. The floats shall be at least 4 feet long. Each transverse pass of the float shall overlap the previous pass by at least half the length of the float. The first floating shall be at right angles to the strike-off. The second floating shall be at right angles to the centerline of the span. A smooth riding surface shall be maintained across construction joints.

Expansion joints shall be finished with a 1/2 inch radius edger.

After floating, but while the concrete remains plastic, the Contractor shall test the entire slab for flatness (allowing for crown, camber, and vertical curvature). The testing shall be done with a 10-foot straightedge held on the surface. The straightedge shall be advanced in successive positions parallel to the centerline, moving not more than one-half the length of the straightedge each time it advances. This procedure shall be repeated with the straightedge held perpendicular to the centerline. An acceptable surface shall be one free from deviations of more than 1/8 inch under the 10-foot straightedge.

If the test reveals depressions, the Contractor shall fill them with freshly mixed concrete, strike off, consolidate, and refinish them. High areas shall be cut down and refinished. Re-testing and refinishing shall continue until an acceptable, deviation free surface is produced. The hardened concrete shall meet all smoothness requirements of these Specifications even though the tests require corrective work.

The Contractor shall texture the bridge deck by combing the final surface perpendicular to the centerline. Made of a single row of metal tines, the comb shall leave striations in the fresh concrete approximately 3/16-inch deep by 1/8-inch wide and spaced approximately 1/2 inch apart. The Engineer will decide actual depths at the site. (If the comb has not been approved, the Contractor shall obtain the Engineer's approval by demonstrating it on a test section.)

The Contractor may operate the combs manually or mechanically, either singly or with several placed end to end. The timing and method used shall produce the required texture without displacing larger particles of aggregate. Texturing shall end 2 feet from curb lines. This 2-foot untextured strip shall be hand finished with a steel trowel.

If the Contract calls for an overlay (to be constructed on the same Contract) such as asphalt concrete, latex modified concrete, epoxy concrete, or similar, the Contractor shall produce the final finish by dragging a strip of damp, seamless burlap lengthwise over the full width of the slab or by brooming it lightly. A burlap drag shall equal the slab in width. Approximately 3 feet of the drag shall contact the surface, with the least possible bow in its leading edge. The burlap shall be kept wet and free of hardened lumps of concrete. When it fails to produce the required finish, the Contractor shall replace it. When not in use, it shall be lifted clear of the slab.

The surface shall not vary more than 1/8-inch under a 10-foot straightedge placed parallel and perpendicular to the centerline after the slab has cured.

The Contractor shall cut high spots down with a diamond faced, saw-type cutting machine. This machine shall cut through mortar and aggregate without breaking or dislodging the aggregate or causing spalls.

Low spots shall be built up utilizing a grout or concrete with a strength equal to or greater than the required 28-day strength of the roadway slab concrete. The method of build-up shall be submitted to the Engineer for approval prior to use.

The surface texture on any area cut down or built up shall match closely that of the surrounding deck. The entire bridge roadway slab shall provide a smooth riding surface.

Concrete for sidewalk slabs shall be well compacted, struck off with a strike-board, and floated with a wooden float to achieve a surface that does not vary more than 1/8-inch under a 10-foot straightedge. An edging tool shall be used to finish all sidewalk edges and expansion joints. The final surface shall have a granular texture that does not turn slick when wet.

6-02.3(11) CURING CONCRETE

6-02.3(11)A GENERAL

After placement, concrete surfaces shall be cured as follows:

Concrete Surface	Curing
Slabs (roadway, except those using Class 4000W[1]; bridge approach slabs, bridge side walks; culvert tops; roofs of cut and cover tunnels)	curing compound covered by white, reflective type sheeting or continuous wet curing for at least 10 days.
Roadway slabs using concrete Class 4000W[1]	continuous wet cure with heavy quilted blankets or burlap only, for 14 days.
Retaining walls, culvert sidewalls, and culvert floors	continuous moisture for at least ten days.

Note 1: water reducing admixture per Section 9-23.6 required.

All other concrete surfaces (except traffic barriers and rail bases) shall be cured with continuous moisture for at least three days.

The Contractor may provide continuous moisture by watering a covering of heavy quilted blankets, by watering and covering with a white reflective type sheeting, or by wetting the outside surfaces of wood forms.

When curing roadway slabs with wet heavy quilted blankets or burlap, a fog or mist spray of water shall be sprayed on the entire concrete surface before the bleed water has evaporated. As soon as the concrete has achieved initial set, the surface shall be covered with presoaked heavy quilted blankets or burlap. The fog or mist spray shall be applied continuously until the presoaked heavy quilted blankets or burlap are placed. If the fog or mist spray cannot be applied continuously, two coats of curing compound (that complies with Section 9-23.2) shall be applied after the initial fog or mist spray application and before the presoaked heavy quilted blankets or burlap are placed.

When using curing compound, the Contractor shall apply two coats of compound to the fresh concrete. The compound shall comply with Section 9-23.2 and shall be applied immediately after finishing and after the visible bleed of water has evaporated. The second coat shall be applied in a pattern perpendicular to that of the first coat. The two coats shall total at least 1 gallon per 150 square feet and shall obscure the original color of the concrete. If any curing compound spills on construction joints or reinforcing steel, the Contractor shall remove the compound from the construction joint or reinforcing steel before the next concrete pour.

Unless the Contract calls for an asphalt overlay, the Contractor shall use white pigmented curing compound (Type 2), agitating it thoroughly just before and during application. If other Material is to bond with the concrete surface, the Contractor shall remove the curing compound by sandblasting or by acceptable high pressure water washing prior to placing the other Material.

The Contractor shall have on-site, back-up spray equipment, enough workers, and a bridge from which they shall apply the curing compound. The Contractor shall be prepared to demonstrate at least one day before the pour, that the workers and equipment can apply the compound as specified. No later than the morning after applying the curing compound, the Contractor shall cover the top surfaces with white, reflective sheeting, leaving it in place for at least ten days. The sheeting shall be kept in place by taping or weighting the edges where they overlap.

If the Contract calls for an asphalt overlay, the Contractor shall use the clear curing compound (Type 1D), applying at least 1 gallon per 150 square feet to the concrete slab.

6-02.3(11)B CURING AND FINISHING CONCRETE TRAFFIC AND PEDESTRIAN BARRIER

The Contractor shall supply enough water and workers to cure and finish concrete barrier as required in this Section.

Fixed-Form Barrier:

The edge chamfers shall be formed by attaching chamfer strips to the barrier forms. After troweling, edging a barrier, and while the forms remain in place, the Contractor shall:

1. Brush the top surface with a fine bristle brush;
2. Cover the top surface with heavy, quilted blankets; and
3. Spray water on the blankets and forms at intervals short enough to keep them thoroughly wet for 3 days.

After removing the forms, the Contractor shall:

1) Remove all lips and edgings with sharp tools or chisels;
2) Fill all holes with mortar;
3) True up corners of openings;
4) Remove concrete projecting beyond the true surface by stoning or grinding;
5) Cover the barrier with heavy, quilted blankets (burlap shall not be used); and
6) Keep the blankets continuously wet for at least 7 days.

The Contractor may do the finishing work described in steps a. through d. after removing the forms if the entire barrier, except for the immediate work area, is kept covered and kept wet. Otherwise, no finishing work may be done until at least 10 days after pouring.

After the 10-day curing period, the Contractor shall remove from the barrier all form-release agent, mud, dust, and other foreign substances in either of two ways: (1) by light sandblasting and washing with water, or (2) by spraying with a high-pressure water jet. The water jet equipment shall use clean fresh water and shall produce (at the nozzle) at least 1500 psi with a discharge of at least 3 gpm. The water jet nozzle shall have a 25-degree tip and shall be held no more than 9 inches from the surface being washed.

After cleaning, the Contractor shall use brushes to rub 1:1 mortar into air holes and small crevices on all surfaces except the brushed top. This mortar shall consist of 1 part Portland cement (of the same brand used in the concrete) and 1 part uncontaminated fine plaster sand. As soon as the mortar takes its initial set, the Contractor shall rub it off with a piece of sacking or carpet. The barrier shall then be covered with wet quilted blankets for at least 48 hours.

No curing compound shall be used on fixed-form concrete barrier. The completed surface of the concrete shall be even in color and texture.

Slip-Form Barrier:

The edge radius shall be formed by attaching radius strips to the barrier slip forming.

The Contractor shall finish slip-form barrier by steel troweling to close all surface pockmarks and holes. The Contractor shall finish plain surface barrier by lightly brushing the front and back face with vertical strokes and the top surface with crosswise strokes.

After finishing, the Contractor shall cure the slip-form barrier by using either method A (curing compound) or method B (wet blankets) described as follows:

Method A: Under the curing compound method, the Contractor shall:

(1) Spray 2 coats of clear curing compound (Type 1D) on the concrete surface after the free water has disappeared (Coverage of combined coats shall equal at least 1 gallon per 150 square feet);

(2) No later than the morning after applying the curing compound, cover the barrier with white, reflective sheeting for at least 10 days; and

(3) After the 10-day curing period, remove the curing compound completely by light sandblasting or by spraying with a high-pressure water jet to produce an even surface appearance. The water jet equipment shall use clean fresh water and shall produce (at the nozzle) at least 2500 psi with a discharge of at least 4 gpm. The water jet nozzle shall have a 25-degree tip and shall be held no more than 9 inches from the surface being cleaned. The Contractor may propose to use a curing compound/concrete sealer. The Engineer will evaluate the Contractor's curing compound concrete sealer submittal and if found acceptable, will approve the proposal in writing. As a minimum, the Contractor’s submittal shall include:
    a) Product Identity,
    b) Manufacturer’s recommended application rate,
    c) Method of application and necessary equipment,
    d) Material Safety Data Sheet (MSDS), and
    e) Sample of the material for testing

Allow 14 Working Days for evaluating the proposal and testing the material.

Method B: Under the wet cure method, the Contractor shall:

a. Provide an initial cure period by continuous fogging or mist spraying for at least the first 24 hours;
b. After the initial cure period, cover the barrier with a heavy quilted blanket; and

c. Keep the blankets continuously wet for at least 10 days. (No additional finishing is required at the end of the curing period.)

6-02.3(12) CONSTRUCTION JOINT

The Contractor may change construction joints indicated on the Drawings by adding, deleting, or relocating. Any request for such changes shall be submitted to the Engineer for review in accordance with Section 1-05.3(5) showing the added, deleted, or relocated construction joints. Such changes to construction joints shall be at the sole risk of the Contractor and shall be at no additional cost to the Owner.

All construction joints shall be formed neatly with grade strips or other approved methods. The Engineer will not accept irregular or wavy construction joints. Wire mesh forming material shall not be used. All joints shall be horizontal, vertical, or perpendicular to the main reinforcement. The Contractor shall not use an edger on any construction joint, and shall remove any lip or edging before making the adjacent pour.

If the Drawings require a roughened surface on the joint, the Contractor shall strike it off to leave grooves at right angles to the length of the member. The grooves shall be 1/2 inch to 1 inch wide, 1/4 inch to 1/2 inch deep, and spaced equally at twice the width of the groove. If the first strike-off does not produce the required roughness, the Contractor shall repeat the process before the concrete reaches initial set. The final surface shall be clean and without laitance or loose material.

The Contractor shall include shear keys at all construction joints where a roughened surface is not required on the Drawings. These shear keys shall provide a positive, mechanical bond. Shear keys shall be formed depressions and the forms shall not be removed until the concrete has been in place at least 12 hours. Forms shall be slightly beveled to ensure ready removal. Raised shear keys are not allowed.

Shear keys for the tops of beams, at tops and bottoms of boxed girder webs, in diaphragms, and in crossbeams shall:

1. Be formed with 2 by 8 inch wood blocks;
2. Measure 8 inches lengthwise along the beam or girder stem;
3. Measure 4 inches less than the width of the stem, beam, crossbeam, etc.(measured transverse of the stem); and
4. Be spaced at 16 inches center to center.
5. In other locations not addressed by items 1, 2, 3, or 4 immediately preceding, shear keys shall equal approximately one third of the joint area and shall be approximately 1-1/2 inches deep, unless the Contract indicates otherwise.

Before placing new concrete against cured concrete, the Contractor shall thoroughly clean and roughen the cured face and wet it with water. Before placing the reinforcing mat for footings on seals, the Contractor shall:

(1) remove all scum, laitance, and loose gravel and sediment;
(2) clean the construction joint at the top of the seals; and
(3) chip off any high spots on the seals that would prevent the footing steel from being placed in the position required by the Drawings.

6-02.3(13) EXPANSION JOINTS AND COMPRESSION SEALS

6-02.3(13)A EXPANSION JOINTS

This Section outlines the requirements of specific expansion joints shown on the Drawings, unless the Contract specifies otherwise.

Joints made of a vulcanized, elastomeric compound (with neoprene as the only polymer) shall be installed with an approved lubricant adhesive as recommended by the manufacturer. The length of a seal shall match that required on the Drawings without splicing or stretching.

Open joints shall be formed with a template made of wood, metal, or other suitable material. Insertion and removal of the template shall be done without chipping or breaking the edges or otherwise damaging the concrete. Joint surfaces shall be parallel with a tolerance varying not more than 1/16 the joint spacing in any 10 foot length.

Any part of an expansion joint running parallel to the direction of expansion shall provide a clearance of at least 1/2 inch between the two surfaces. The clearance shall be produced by inserting and removing a spacer strip. The Contractor shall ensure that the surfaces meet the parallel requirements to prevent any wedging from expansion and contraction.

All poured rubber joint sealer (and any required primer) shall conform with Section 9-04.2(2).

The expansion joints shall be as shown and noted on the Drawings.

The Contractor shall submit Shop Drawings of the expansion joints proposed for use to the Engineer. Submittal of Shop Drawings shall be in accordance with provisions of Section 1-05.3. The Shop Drawings shall show details of the system(s), including materials and dimensions, method of installation, method of sealing the system to prevent leakage of water through the joint, and the manufacturer's written installation procedures.

After the joint system(s) is installed, the joint area shall be sandbagged, flooded with 4 inches of water for 24 hours and inspected from below the joint for leakage. If leakage is observed, the joint system shall be repaired as recommended by the manufacturer including review of the manufacturer's recommendation by the Engineer.

To aid in assuring proper use and installation of the expansion joint system under job conditions, the Contractor shall have available during installation of the joint system and at no additional cost to the Owner, the services of a qualified, full-time field representative of the manufacturer of the expansion joint system to be installed in the project. Recommendations made by the manufacturer's representative and reviewed by the Engineer, shall be adhered to by the Contractor at no additional cost to the Owner.

The expansion joints shall seal the roadway deck surface, curbs, and sidewalks to prevent water from passing through the joint to portions of the Structure below. Installation of the expansion joints and painting of the exposed metal parts shall be in accordance with the manufacturer's recommendations. The sealant recommended by the manufacturer supplying the expansion joint shall be submitted for review by the Engineer before installation. The transition of the expansion joint from the roadway, up the curb face and horizontally to the back of the curb shall be in a continuous factory fabricated curb/gutter unit.

The seats for the expansion joints shall be absolutely parallel to longitudinal and transverse roadway grade and shall match the transverse crown of the final pavement surface. All spalls, low areas or high areas in the expansion joint seat shall be recontoured so that the variation is no more than 1/16 inch from a 10-foot straightedge on a constant cross slope and from a 3-foot straightedge on a parabolic crown. Each successive check with the straightedge device shall lap the previous check by at least 1/2 of the length of the straightedge. All concrete outside corners of the expansion joint slot shall have a radius of rounding of 1/4 inch.

When the expansion joint seat consists of steel plates or steel angles, all high areas shall be ground and all low areas having a depth of less than 1/4 inch from the true seat contour shall be filled with an approved epoxy. Areas with a depth greater than 1/4 inch shall be filled with an approved epoxy sand grout. The tolerance from a 10-foot or 3-foot straightedge shall be the same as stated above for concrete seats.

The expansion joint material shall have full firm bearing for the entire length and width of the joint. The expansion joint material shall be placed so that its top surface is recessed 1/8 inch ±1/16 inch below the driving surface of the pavement on both sides of the expansion joint.

Shims, washers or other devices shall not be used below the expansion joint material to bring the joint either to proper elevation or to proper tolerance.

All aluminum surfaces that will be in contact with concrete shall be coated with zinc chromate or a bituminous paint as recommended by the manufacturer.

6-02.3(13)B COMPRESSION SEAL

6-02.3(13)B1 GENERAL

The groove or recess for compression seals shall have parallel sides and be constructed to the proper depth. The width of the recess shall not vary more than 1/16 inch in a distance of 10 feet. The bottom shall be a smooth surface parallel to the surface of the roadway, curb, or sidewalk.

The Contractor shall furnish and install compression seals of the size and type specified at the locations indicated on the Drawings and according to the following provisions:

The seals shall conform to the requirements of ASTM D 2000 and shall be formed by an extrusion process resulting in a dense neoprene with uniform dimensions and smooth exterior surface.

The cross section of the seal shall be shaped to allow adequate compression of the seal under design conditions. The length of seals shall be as indicated on the Drawings. Stretching of the seals will not be permitted. Details of the seal, including corner joints and type of material to bond joints shall be submitted to the Engineer for review before submitting samples for lot acceptance. A lot shall be considered all material of one size produced during one production run for use on the project. A sample shall consist of a 3-foot length of actual seal. The Supplier of the joint seals shall furnish the Engineer a Manufacturrer's Certificate of Compliance stating the test results for the Material complies with the Specification requirements including catalog cuts and Shop Drawings.

The seal shall be installed with an approved lubricant adhesive in accordance with the manufacturer's recommendations. The lubricant adhesive shall be delivered in containers plainly marked with the manufacturer's name or trademark, lot number and date of manufacture. A one pint sample of lubricant adhesive shall be furnished to the Engineer for approval prior to installation.

6-02.3(13)B2 PREPARATION OF SURFACES FOR INSTALLATION

All surfaces to receive elastomeric compression seal shall be free from dirt, water, oil, rust, frost, spalls, cracks, and any loose debris.

It is imperative that a clean opening, with 1/4 inch rounded top edges, shall be produced for the specified opening and for the full depth of joint required. All joint grooves shall be inspected for spalling after the joints are constructed and all foreign materials removed from the joint grooves. Spalling that increases the specified size of the joint groove beyond the following limits shall be repaired by patching with epoxy mortar:

1. Spalls over 1/4 inch wide and over 1/2 inch below the surface of the pavement; and
2. Spalls over 1/4 inch wide and 2 inches or more in length, regardless of the depth of spall below the surface of the pavement.

6-02.3(13)B3 INSTALLATION

Where indicated on the Drawings, the Contractor shall install the proper seals in accordance with the Contract. The air temperature shall be below 85°F at the time of installation.

Compression seals shall be recessed 3/8 inch from the finished grade with a tolerance of 1/16 inch in 10 feet.

At end joints or miter joints as shown on the Drawings, a 1/4-inch thick neoprene sponge shall be bonded to the seal ends with an approved cyanoacrylate adhesive. The neoprene sponge shall be cut to the size and shape of the nominal dimensions of the uncompressed seal. The seal plus the sponge shall be slightly longer than the gap to be filled so that the sponge is in a state of compression against the ends of the seal. The cyanoacrylate adhesive shall only be applied to outer webs and top web of the seal to allow entrapped air to escape.

At seal upturn or downturn locations, the installation procedure shall be as follows (see detail on the Drawings):

1. Locate 1/2-inch diameter hole and drill through seal as shown, using a standard twist drill;
2. Using a sharp long blade knife or hacksaw, cut lower section of seal to 1/2-inch diameter hole as shown;
3. Bend seal in desired position and install as shown; and
4. Complete seal installation following normal sealing instructions.

The seal surface to be bonded shall be cleaned with toluene or other solvent recommended by the seal manufacturer prior to applying adhesive. Controls shall be in place for controlling and containing the toluene or other solvent material as required in Section 1-07. A continuous coat of adhesive shall be applied to both joint interfaces immediately prior to seal installation. Adhesive shall not be applied below 40°F. The compression seal shall be placed such that the top surface, or surface facing the front of the curb, shall be recessed 1/8-inch ±1/16 inch into the adjacent concrete surface.

6-02.3(14) FINISHING CONCRETE SURFACES

6-02.3(14)A GENERAL

All concrete shall show a smooth, dense, non-porous face after the forms are removed. The removing and replacing of any concrete showing porous, or not smooth, or non-dense concrete shall be at no additional cost to the Owner. The Contractor shall clean and refinish any stained or discolored surfaces that may have resulted from his/her work or from construction delays.

Subsections 6-02.3(14)B, 6-02.3(14)C, and 6-02.3(14)D describe three classes of surface finishing. The Contractor shall comply with these subsections unless the Contract requires otherwise.

6-02.3(14)B CLASS 1 SURFACE FINISH

The Contractor shall apply a Class 1 surface finish to all rail bases, curbs, traffic barrier, pedestrian barrier, and ornamental concrete members.

Class 1 surface finish requires the same treatment as Class 2 surface finish (see the following Section) but also includes the finishing steps outlined in Section 6-02.3(11)B.

6-02.3(14)C CLASS 2 SURFACE FINISH

The Contractor shall apply a Class 2 surface finish to:

1. All surfaces on the superstructures at highway grade separations and railroad undercrossings (but not under surfaces of slab spans, filled spandrel arches and floor slabs between girders, or near horizontal bottom slabs of box girders, or inside vertical surfaces of girders, or concrete cast in steel forms);
2. All above finished ground surfaces of bridge piers, columns, abutments, retaining walls, and Culvert head walls, but not columns cast in steel forms, whenever these surfaces are visible from any walkway or roadway within 150 feet;
3. All outside surfaces, vertical or sloping, of each superstructure including the undersurfaces of cantilevered floor slabs that overhang outside girders or box girders; and
4. All surfaces of open spandrel arch rings, spandrel columns, and abutment towers.

The Contractor shall comply with steps a. through h. that follow. The Contractor may omit steps c. through h. below when steel forms have been used and when the surface of filled holes matches the texture and color of the area around them. To create a Class 2 surface finish, the Contractor shall:

a. Remove all bolts and all lips and edgings where form members have met;
b. Fill all holes greater than 1/4-inch with 1:2 mortar floated to an even, uniform finish that is flush with surrounding surface;
c. Thoroughly wash the surface of the concrete with water;
d. Brush on a 1:1 mortar mix (made of the same brand of cement as was used in the concrete), working it well into the small air holes and other crevices in the face of the concrete;
e. Brush on no more mortar than can be finished in 1 day;
f. Rub the mortar off with burlap or a piece of carpet as soon as it takes initial set and before it reaches final set;
g. Fog-spray water over the finish as soon as the mortar paint has reached final set; and
h. Keep the surface damp for at least 2 days.

If the mortar becomes too hard to rub off as described in step f., the Contractor shall remove it with a carborundum stone and water. Random grinding is not permitted.

6-02.3(14)D CLASS 3 SURFACE FINISH

The Contractor shall apply a Class 3 surface finish to:

1. All above-ground surfaces not receiving a Class 1 or Class 2 surface finish as specified above; and
2. All surfaces that are to be underground or covered with fill. The Engineer may waive the requirement for removing tight form ties and filling small air holes.

To produce a Class 3 surface finish, the Contractor shall:

1) Remove all bolts and all lips and edgings where form members have met; and
2) Fill all holes greater than 1/4-inch with 1 part Portland cement to 2 part fine aggregate (Section 9-03.1(2)) mortar with just enough water to make a stiff consistency floated to an even, flush finish.

Nothing further is required if the Engineer decides these 2 steps have produced an acceptable surface finish. Otherwise, the Contractor shall follow other Class 2 surface finish steps until the Engineer approves the work as a final Class 3 surface finish.

6-02.3(15) DATE NUMERALS

Standard date numerals shall be placed where shown on the Drawings. The date shall be for the year in which the Structure is completed. When a traffic barrier is placed on an existing Structure, the date shall be for the year in which the original structure was completed.

6-02.3(16) SHOP DRAWINGS FOR FALSEWORK AND FORMWORK

6-02.3(16)A GENERAL

The Contractor shall submit all Shop Drawings for falsework and formwork for review directly to the Engineer in accordance with Section 1-05.3. All falsework and formwork shall be constructed in accordance with Engineer reviewed falsework and formwork Shop Drawings.

Except for the placement of falsework foundation pads and piles, the construction of any unit of falsework shall not start until the Engineer has reviewed the falsework Shop Drawing submittal for that unit. Driven piles for falsework, temporary concrete footings, or timber mudsills may be placed as described in Section 6-02.3(17)E prior to the Engineer's review at the Contractor's own risk, except for the following conditions:

1. The falsework is over or adjacent to roadways or railroads as described in Section 6-02.3(17)D; or
2. The falsework requires prior placement of shoring or cofferdams as described in Section 2-09.3(3)D.

If the project involves a railroad or the U.S. Bureau of Reclamation, the following additional sets for the portion of the project that involves the railroad or U.S. Bureau of Reclamation shall be sent to the Engineer:

1) Four sets for each railroad company affected; and
2) Six sets for the U.S. Bureau of Reclamation.

The Engineer will review the falsework and formwork Shop Drawings and calculations, and will request the required reviews from the appropriate railroad company or the U.S. Bureau of Reclamation. After the Engineer has received any comments from the railroad company or the U.S. Bureau of Reclamation, two copies of the reviewed falsework and formwork Shop Drawings, with comment when applicable, will be returned to the Contractor.

Shop Drawing review is not required for footing or retaining walls unless they are more than 4 feet high excluding pedestal height.

The design of falsework and formwork shall be based on:

(1) Applied loads and conditions which are no less severe than those described in Section 6-02.3(17)B, "Design Loads;"
(2) Allowable stresses and deflections which are no greater than those described in Section 6-02.3(17)C, "Allowable Stresses and Deflections;"
(3) Special loads and requirements no less severe than those described in Section 6-02.3(17)D, "Falsework and Formwork at Special Locations;" and
(4) Conditions required by other Sections of 6-02.3(17), "Falsework and Formwork".

The falsework and formwork Shop Drawings shall be scale drawings showing the details of proposed construction, including, but not limited to.

a. sizes and properties of all members and components;
b. spacing of bents, posts, studs, wales, stringers, wedges and bracing;
c. rates of concrete placement, placement sequence, direction of placement, and location of construction joints; and
d. identify falsework devices and safe working load as well as identifying any bolts or threaded rods used with the devices including their diameter, length, type, grade, and required torque.

Show in the falsework Shop Drawing submittals the proximity of falsework to utilities or any nearby Structures including underground Structures. Formwork accessories shall be identified according to Section 6-02.3(17)I, "Formwork Accessories". All assumptions, dimensions, material properties, and other data used in making the structural analysis shall be noted on the Shop Drawing submittal.

In accordance with the requirements of Section 1-05.3(12), all falsework and formwork Shop Drawings and design calculations shall be prepared by (or under the direct supervision of) a Professional Engineer, licensed under Title 18 RCW, State of Washington, in the branch of Civil or Structural Engineering. The Contractor shall furnish two copies of the associated design calculations to the Engineer for examination as a condition for review. The design calculations shall show the stresses and deflections in load supporting members. Construction details which may be shown in the form of sketches on the calculation sheets shall be shown in the falsework or formwork Shop Drawings as well. Falsework or formwork Shop Drawings will not be reviewed in any case where it is necessary to refer to the calculation sheets for information needed for complete understanding of the falsework and formwork Shop Drawings or how to construct the falsework and formwork.

6-02.3(16)B REVISED AND PRE-APPROVED FALSEWORK AND FORMWORK SHOP DRAWINGS

Pre-approval of falsework and formwork Shop Drawings will not be allowed.

Contractor revisions to reviewed Shop Drawings returned by the Engineer shall require a resubmittal of the reviewed Shop Drawings clearly indicating all revision with supporting calculation. The Contractor shall take into consideration any additional time required by the Engineer to perform additional review of previously reviewed Shop Drawings. The Contractor agrees to make no claim whatsoever both for adjustment to Contract Time and/or for additional compensation.

6-02.3(17) FALSEWORK AND FORMWORK

6-02.3(17)A GENERAL

Formwork and falsework are both structural systems. Formwork contains the lateral pressure exerted by concrete placed in the forms. Falsework supports the vertical and/or the horizontal loads of the formwork, reinforcing steel, concrete, and live loads during construction.

The Contractor shall set falsework, to produce in the finished structure, the lines and grades indicated on the Drawings. The setting of falsework shall allow for shrinkage, settlement, falsework girder camber, and any structural camber the Contract requires.

Concrete forms shall be mortar tight and true to the dimensions, lines, and grades of the concrete structure. Curved surfaces shown on the Drawings shall be constructed as curved surfaces and not chorded, except as allowed in Section 6-02.3(17)K. Concrete formwork shall prevent overstress and excess deflection as defined in Section 6-02.3(17)C. The rate of depositing concrete in the forms shall not exceed the placement rate in the submitted and reviewed formwork Shop Drawing. The interior form shape and dimensions shall also ensure that the finished concrete conforms with the Drawings.

If the new Structure is near or part of an existing one, the Contractor shall not suspend or support falsework on the existing structure unless the Contract states otherwise. For prestress girder and T-beam bridge widenings or stage construction, the roadway deck and the diaphragm forms may be supported from the existing structure or previous stage, if approved by the Engineer. For steel plate girder bridge widenings or stage construction, only the roadway deck forms may be supported from the existing structure or previous stage, if approved by the Engineer. See Section 6-02.3(17)F for additional conditions.

Forms designed to stay in place on bridge roadway slabs shall not be made of steel or precast concrete panels.

For post-tensioned structures, both falsework and forms shall be designed to carry the additional loads caused by the post-tensioning operations. The Contractor shall construct supporting falsework in a way that leaves the superstructure free to contract and lift off the falsework during post-tensioning. Forms that remain inside box girders to support the placement of the roadway slab concrete shall, by design, not resist girder contraction. See Section 6-02.3(26) for additional conditions.

Concrete barriers shall be used to protect falsework adjacent to traffic from damage by vehicles.

6-02.3(17)B DESIGN LOADS

The design load for falsework shall consist of the sum of dead and live vertical loads, and a design horizontal load. The minimum total design load for any falsework shall not be less than 100 pounds per square foot for combined live and dead load regardless of structure thickness.

The entire superstructure cross-section, except for traffic barrier, shall be considered to be placed at one time for purposes of determining support requirements and designing falsework girders for their stresses and deflections, except as follows:

> For concrete box girder bridges, the girder stems, diaphrams, crossbeams, and connected bottom slabs, if the stem wall is placed more than 5 days prior to the top slab, may be considered to be self supporting between falsework bents at the time the top slab is placed, provided that the distance between falsework bents does not exceed 4 times the depth of the portion of the girder placed in the preceding concrete placements.

Falsework bents shall be designed for the entire live load and dead load, including all load transfer that takes place during post-tensioning, and braced for the design horizontal load.

Dead loads shall include the weight of all successive placements of concrete, reinforcing steel, forms and falsework, and all load transfer that takes place during post-tensioning. The weight of concrete with reinforcing steel shall be assumed to be not less than 160 pounds per cubic foot.

Live loads shall consist of the actual weight of any equipment to be supported by falsework applied as concentrated loads at the points of contact, and a minimum uniform load of not less than 25 pounds per square foot applied over the entire falsework Shop Drawing submittal area supported, plus a minimum load of not less than 75 pounds per linear foot applied at the outside edge of deck overhangs.

The design horizontal load to be resisted by the falsework bracing system in any direction shall be:

> The sum of all identifiable horizontal loads exerted by equipment, construction sequence, sidesway caused by geometry or eccentric loading conditions, or other causes, and an allowance for wind plus an additional allowance of 1 percent of the total dead load to provide for unexpected forces. In no case shall the design horizontal load be less than three percent of the total dead load.

The minimum horizontal load to be allowed for wind on each heavy-duty steel shoring tower having a vertical load carrying capacity exceeding 30 kips per leg shall be the sum of the products of the wind impact area, shape factor, and the applicable wind pressure value for each height zone. The wind impact area is the total projected area of all the elements in the tower face normal to the applied wind. The shape factor for heavy-duty steel shoring towers shall be taken as 2.2. Wind pressure values shall be determined from the following table:

WIND PRESSURE ON HEAVY-DUTY STEEL SHORING TOWERS		
Height Zone (Feet above Ground)	**Wind Pressure Value**	
	Adjacent to Traffic	**At Other Locations**
0 to 30	20 psf	15 psf
30 to 50	25 psf	20 psf
50 to 100	30 psf	25 psf
Over 100	35 psf	30 psf

The minimum horizontal load to be allowed for wind on all other types of falsework, including falsework girders and forms supported on heavy-duty steel shoring towers, shall be the sum of the products of the wind impact area and the applicable wind pressure value for each height zone. The wind impact area is the gross projected area of the falsework support system, falsework girders, forms and any unrestrained portion of the permanent structure, excluding the areas between falsework posts or towers where diagonal bracing is not used. Wind pressure values shall be determined from the following table:

WIND PRESSURE ON ALL OTHER TYPES OF FALSEWORK		
Height Zone(Feet above Ground)	**Wind Pressure Value**	
	For Members Over and Bents Adjacent to Traffic Openings	**At Other Locations**
0 to 30	2.0 Q psf	1.5 Q psf
30 to 50	2.5 Q psf	2.0 Q psf
50 to 100	3.0 Q psf	2.5 Q psf
Over 100	3.5 Q psf	3.0 Q psf

The value of Q in the above tabulation shall be determined as follows:

$Q = 1 + 0.2W$; but Q shall not be more than 10.

Where: W is the width of the falsework system, in feet, measured in the direction of the wind force being considered.

The falsework system shall also be designed so that it is sufficiently stable to resist overturning prior to the placement of the concrete. The minimum factor of safety against falsework overturning in all directions from the assumed horizontal load for all stages of construction shall be 1.25. If the required resisting moment is less than 1.25 times the overturning moment, the difference shall be resisted by bracing, cable guys, or other means of external support.

Design of falsework shall include the vertical component, whether positive or negative, of bracing loads imposed by the design horizontal load. Design of falsework shall include the effects of any horizontal displacement due to stretch of the bracing, particularly when using cable or rod bracing systems.

If the concrete is to be post-tensioned, the falsework shall be designed to support any increased or redistributed loads caused by the prestressing forces.

6-02.3(17)C ALLOWABLE DESIGN STRESSES AND DEFLECTIONS

The maximum allowable stresses listed in this Section are based on the use of identifiable, undamaged, high-quality materials. Stresses shall be appropriately reduced if lesser quality materials are to be used.

These maximum allowable stresses include all adjustment factors, such as the short term load duration factor. The maximum allowable stresses and deflections used in the design of the falsework and formwork shall be as follows:

Deflection:

Deflection resulting from dead load and concrete pressure for exposed visible surfaces, such as the sides and bottoms of girders, regardless of the fact that the deflection due to the weight of all successive placements of concrete, reinforcing steel and forms may be compensated for by camber strips; sides of abutments, wingwalls, piers, retaining walls, and columns = 1/500 of the span.

Deflection resulting from dead load and concrete pressure for unexposed non-visible surfaces, including the bottom of the deck slab between girders, regardless of the fact that the deflection due to the weight of all successive placements of concrete, reinforcing steel and forms may be compensated for by camber strips = 1/360 of the span.

In the foregoing, the span length shall be the center line to center line distance between supports for simple and continuous spans, and from the center line of support to the end of the member for cantilever spans. For plywood supported on members wider than 1-1/2 inches, the span length shall be taken as the clear span plus 1-1/2 inches. Also, dead load shall include the weight of all successive placements of concrete, reinforcing steel, forms and falsework self weight. Only the self weight of falsework girders may be excluded from the calculation of the above deflections provided that the falsework girder deflection is compensated for by the installation of camber strips.

Where successive placements of concrete are to act compositely in the completed structure, deflection control becomes extremely critical. For members constructed in several successive placements, such as concrete box girder and concrete T-beam girder structures, falsework components shall be sized, positioned, and/or supported to minimize progressive increases in deflection of the structure which would preload the concrete or reinforcing steel before it becomes fully composite.

Timber:

Each species and grade of timber or lumber used in constructing falsework and formwork shall be identified in the Shop Drawings. The allowable stresses and loads shall not exceed the lesser of stresses and loads given in the following table or factored stresses for designated species and grade in Table 7.3 of the Timber Construction Manual, Third Edition by the American Institute of Timber Construction.

Compression perpendicular to the grain reduced to 300 psi for use when moisture content is 19 percent or more (areas exposed to rain, concrete curing water, green lumber).	450 psi
Compression parallel to the grain but not to exceed 1,500 psi.	$\frac{480{,}000\text{ psi}}{(L/d)^2}$
Flexural stress for members with a nominal depth greater than 8 inches.	1,800 psi
Flexural stress psi for members with a nominal depth of 8 inches or less.	1,500 psi
The maximum horizontal shear.	140 psi
AXIAL tension.	1,200 psi
The maximum modulus of elasticity (E) for timber.	1,600,000 psi

Where:

L is the unsupported length; and

d is the least dimension of a square or rectangular column, or the width of a square of equivalent cross-sectional area for round columns.

The allowable stress for compression perpendicular to the grain, and for horizontal shear shall not be increased by any factors such as short duration loading. Additional requirements are found in other parts of Section 6-02.3(17). Criteria for the design of lumber and timber connections are found in Section 6-02.3(17)J.

Plywood for formwork shall be designed in accordance with the methods and stresses allowed in the APA Design/Construction Guide for Concrete Forming as published by the American Plywood Association, Tacoma, Washington. As concrete forming is a special application for plywood, wet stresses shall be used and then adjusted for forming conditions such as duration of load, and experience factors. Concrete pour pressures shall be per Section 6-02.3(17)K.

Steel:

For identified grades of steel, design stresses shall not exceed those specified in the Manual of Steel Construction - Allowable Stress Design, Ninth Edition by the American Institute of Steel Construction, except as follows:

Compression, flexural but not to exceed $0.6F_y$	$\frac{12{,}000{,}000\text{ psi}}{Ld/bt}$
The modulus of elasticity (E) shall be	29,000,000 psi

When the grade of steel cannot be positively identified as with salvaged steel and if rivets are present, design stresses shall not exceed the following:

Yield point f_y ....30,000 psi
Tension, axial, and flexural...16,000 psi
Compression, axial...$14{,}150 - 0.37(KL/r)^2$ psi
except L/r shall not exceed 120
Shear on gross section of the web of rolled shapes.....................9,500 psi
Web crippling for rolled shapes...22,500 psi
Compression, flexural but not to exceed.......................................$16{,}000 - 5.2(L/b)^2$ psi
....16,000 psi and L/b not greater than 39
The modulus of elasticity (E) shall be..29,000,000 psi

Where:

L is the unsupported length;

d is the least dimension of rectangular columns, or the width of a square of equivalent cross-sectional area for round columns, or the depth of beams;

b is the flange width;

t is the thickness of the compression flange;

r is the radius of gyration of the compression flange about the weak axis of the member; and

F_y is the specified minimum yield stress, psi, for the grade of steel used.

All dimensions are expressed in inches.

6-02.3(17)D FALSEWORK AND FORMWORK AT SPECIAL LOCATIONS

In addition to the minimum requirements specified in Sections 6-02.3(17)B and 6-02.3(17)C, falsework over or adjacent to roadways or railroads which are open to traffic or the public shall be designed and constructed so that the falsework is stable if subjected to impact by vehicles. The use of damaged materials, unidentifiable material, salvaged steel or steel with burned holes or questionable weldments shall not be used for falsework described in this Specification Section.

For the purposes of this Specification Section, the following public or private facilities shall also be considered as "roadways":

pedestrian pathways and other Structures such as bridges, walls, and buildings.

The dimensions of the clear openings to be provided through the falsework for roadways, railroads, or pedestrian pathways shall be as specified in Contract.

Falsework posts or shoring tower systems which support members that cross over a roadway or railroad shall be considered as adjacent to roadways or railroads. Other falsework posts or shoring towers shall be considered as adjacent to roadways or railroads only if the following conditions apply:

1. Located in the row of falsework posts or shoring towers nearest to the roadway or railroad; and
2. Horizontal distance from the traffic side of the falsework to the edge of pavement is less than the total height of the falsework and forms; or
3. The total height of the falsework and forms is greater than the horizontal clear distance between the base of the falsework and a point 10 feet from the centerline of track.

The Contractor shall provide any additional features for the work needed to ensure that the falsework is stable for impact by vehicles; providing adequate safeguards, safety devices, protective equipment, and any other needed actions to protect property and the life, health, and safety of the public; and shall comply with the provisions in Section 1-07.23, Section 1-10, and Section 6-02.3(17)N. The falsework design at special locations, shall incorporate the minimum requirements detailed in this Section, even if protected by concrete median barrier.

The vertical load used for the design of falsework posts and towers which support the portion of the falsework over openings, shall be the greater of the following:

1) 150 percent of the design load calculated in accordance with Section 6-02.3(17)C, but not including any increased or redistributed loads caused by the post-tensioning forces; or
2) 100 percent of the design load plus the increased or redistributed loads caused by the post-tensioning forces.

Each falsework post or each shoring tower leg adjacent to roadways or railroads shall consist of either steel with a minimum section modulus about each axis of 9.5 inches cubed (or 9.5 $inch^3$) or sound timbers with a minimum section modulus about each axis of 250 inches cubed (or 250 $inch^3$).

Each falsework post or shoring tower leg adjacent to roadways or railroads shall be mechanically connected to its supporting footing at its base, or otherwise laterally restrained, to withstand a load of not less than 2,000 pounds applied at the base of the post or tower leg in any direction except toward the roadway or railroad track. Posts or tower legs shall be connected to the falsework cap and stringer by mechanical connections Capable of resisting a load in any horizontal direction of not less than 1,000 pounds.

For falsework spans over roadways and railroads, all falsework stringers shall be mechanically connected to the falsework cap or framing. The mechanical connections shall be Capable of resisting a load in any direction, including uplift on the stringer, of not less than 500 pounds. All associated connections shall be installed before traffic is allowed to pass beneath the span.

When timber members are used to brace falsework bents which are located adjacent to roadways or railroads, all connections shall be bolted through the members using 5/8-inch diameter or larger bolts.

Concrete traffic barrier shall be used to protect all falsework adjacent to traveled roadways. The falsework shall be located so that falsework footings, mudsills, or piles are at least 2 feet clear of the traffic barrier and all other falsework members shall also be at least 2 feet clear of the traffic barrier. Traffic barrier used to protect falsework shall not be fastened, guyed, or blocked to any falsework but shall be fastened to the pavement according to details shown on the Drawings. The installation of concrete traffic barrier shall be completed before falsework erection is begun. The traffic barrier at the falsework shall not be removed until approved by the Engineer. Falsework openings which are provided for the Contractor's own use (not for public use) shall also use concrete traffic barrier to protect the falsework, except the minimum clear distance between the barrier and falsework footings, mudsills, piles, or other falsework members shall be at least 3 inches.

Falsework bents within 20 feet of the center line of a railroad track shall be braced to resist the required horizontal load or 2,000 pounds whichever is greater.

In addition to the requirements of Section 1-07.23, pedestrian openings through falsework shall be paved or surfaced with full width continuous wood walks which shall be wheel chair accessible and shall be kept clear. Pedestrians shall be protected from objects and water falling from construction above. Overhead protection for pedestrians shall extend at least 4 feet beyond the edge of the bridge deck. Shop Drawings and details of the overhead protection and pathway shall be submitted with the falsework Shop Drawing submittals to the Engineer for review. Pedestrian openings through falsework shall be illuminated by temporary lighting, constructed and maintained by the Contractor. The temporary lighting shall be constructed in accordance with local electrical code requirements. The temporary lighting shall be steady burning and shall be a minimum 60 watt, 120 volt lamps with molded waterproof lamp holders spaced at 25 feet centers maximum. All costs relating to pedestrian pathway paving, wood walks, overhead protection, maintenance, operating costs, and temporary pedestrian lighting shall be incidental to applicable Bid items of Work and shall be at no additional cost to the Owner.

6-02.3(17)E FALSEWORK SUPPORT SYSTEMS: PILES, TEMPORARY CONCRETE FOOTINGS, TIMBER MUDSILLS, MANUFACTURED SHORING TOWERS, CAPS, POSTS

The Contractor shall support all falsework on either driven piles, temporary concrete footings, or timber mudsills. Temporary concrete footings shall be designed as reinforced concrete which may be either cast in place or precast. All components for a falsework support system shall be sized for the maximum design loads and allowable stresses described in the preceding Sections.

The falsework Shop Drawing submittals shall include a superstructure placing diagram showing the concrete placing sequence, direction of placements, and construction joint locations. When a sequence for placing concrete is shown in the Contract, no deviation will be permitted.

If the Contract calls for piles or foundation shafts to support permanent structures, the Contractor may not use mudsills or temporary concrete footings for falsework support unless the underlying soil passes the settlement test described in this Section.

Piles:

When using piles to support the falsework, the Contractor's falsework Shop Drawing submittal shall specify the minimum required bearing and depth of penetration for the piles. The falsework Shop Drawing submittals shall also show the maximum horizontal distance that the top of a falsework pile may be pulled in order to position it under its cap. The falsework Shop Drawing submittal shall show the maximum allowable deviation of the top of the pile, in its final position, from a vertical line through the point of fixity of the pile. The calculations shall account for pile stresses due to combined axial and flexural stress and secondary stresses.

Untreated timber piles shall be banded at the top before driving. The following shall be identified in the falsework Shop Drawing submittal: lengths, minimum tip diameter, and expected diameter at ground line. The Contractor shall comply with the requirements of Section 9-10.1(1). The maximum allowable load for timber piles shall be 45 tons.

Steel piles shall be identified in the falsework Shop Drawing submittal. If steel pipe pile is used, the pipe diameter and wall thickness shall be identified in the falsework Shop Drawing submittal. Steel piles shall meet the requirements of Section 9-10.5. The applicable Specifications in Section 6-05 shall be used to determine the bearing capacity of the falsework piles. The pile bearing capacity may instead be determined by test loading the pile to twice the falsework design load if approved in writing by the Engineer. The Contractor shall provide the Engineer an opportunity to witness these tests and to submit a plan of the test and cross-sections showing the locations and elevations of the proposed tests to the Engineer for approval.

Temporary Concrete Footings and Timber Mudsills:

Timber mudsills or temporary concrete footings may be used in place of driven piles if Contractor provided tests show that the soil can support twice the falsework design load, and that the mudsill or temporary concrete footing shall not settle more than 1/4-inch when loaded with the design load. The tests shall be done at the falsework site, at the same elevation of the mudsill, and conducted under conditions representative of the actual site conditions. The acceptable tests for various soil types are:

1. **Granular Soil** - The Contractor shall conduct on-site tests according to the AASHTO T 235 "Standard Method Test for Bearing Capacity of Soil for Static Load on Spread Footings". The Contractor shall provide 2 Working Days advance notice for the Engineer to witness these tests, and shall submit a plan of the test and cross-sections showing the locations and elevations of the proposed tests to the Engineer for approval at least 5 Working Days in advance.
2. **Fine Grained or Organic Soil** - The Contractor shall employ a geotechnical engineer licensed as a Professional Engineer in the State of Washington to investigate the foundation soils and shall present certification in writing that each mudsill or temporary footing shall meet the load-settlement requirements described above. The allowable bearing capacities, elevations and locations of specific falsework mudsills shall be listed in the certification. Soils information used to determine the soil bearing capacity and settlement shall be submitted with the written certification to the Engineer for review and approval.

Timber mudsills or temporary concrete footings for falsework shall be designed to carry the loads imposed upon them without exceeding the estimated soil bearing capacity and specified maximum settlement. Where mudsills or temporary footings are used in the vicinity of permanent spread footings, the allowable mudsill bearing pressure shall be less than that of the permanent footings. This is because elevation difference; smaller bearing area; and the lack of surrounding overburden provides a lower bearing capacity than the permanent spread footings. Mudsills shall be designed for bearing capacities at the location that they are to be used. Timber mudsills or temporary concrete footings shall be designed as unyielding foundations under full design loads. The soil pressure bearing values assumed in the design of the falsework (normally not more than 3,000 pounds per square foot) shall be shown in the falsework Shop Drawing submittals. The minimum edge distances from the edge of the post or shoring tower leg to the edge or end of the mudsill member shall be shown in the falsework Shop Drawing submittals. Timber mudsills and temporary concrete footings shall be designed such that member deflections do not exceed 1/4-inch and that member allowable stresses are not exceeded.

Full cross-sectional views of all falsework on timber mudsills or temporary concrete footings to be placed in side slopes or above excavations shall be shown in the falsework Shop Drawing submittals. Footings or mudsills which are stepped or placed above an excavation shall have all related geometry and slope stability items identified in the falsework

Shop Drawing submittal. Details and calculations for any shoring system to support the embankment or excavation shall be included.

Mudsills or temporary concrete footings placed in benches in slopes shall be set back from the face of the slope one-half the mudsill or temporary concrete footing width, but not less than 1 foot 0 inch. The bench including the setback shall be level in its narrow dimension. Slopes between benches measured from the top of slope at one bench to the toe of slope at the next bench below shall be no steeper than 1-1/2 horizontal to 1 vertical.

Falsework shall be founded on a solid footing, safe against undermining, protected from softening, and Capable of supporting the loads imposed. The preparation of the soil to receive the temporary footing is important to ensure that the falsework does not experience localized settlement that could result in falsework failure. In preparing the soil for a timber mudsill or temporary concrete footing, the Contractor shall:

1) Place mudsills or footing on dry soil that is either undisturbed or compacted to 95 percent of maximum density, as determined by the compaction control tests in Section 2-03.3(14)E performed by the Contractor and submitted to the Engineer for review;
2) Place mudsills or footings level with full contact bearing on the soil with no voids. Place each distribution plate or corbel member between the post or tower leg and the mudsill members such that there is full contact bearing;
3) Place grout or a compacted layer of fine material under the mudsill if it is supported by rock or coarse sand and gravel;
4) Provide the Engineer with a sample of any off-site material to be used under the mudsill;
5) Allow up to five Working Days for the Engineer's review before using the off-site material; and
6) Provide erosion control measures to protect the soil of the mudsill or footing from undermining and softening.

Anticipated total settlements and incremental settlements of falsework and forms due to successive concrete placements shall be shown in the falsework Shop Drawing submittals. These shall include falsework footing settlement and joint take-up. Total anticipated settlements shall not exceed one inch including joint take-up. When using mudsills, the Contractor shall prepare for the possibility of reshoring with the use of such devices as screw jacks or hydraulic jacks and adjustment of wedge packs. The placing of concrete shall be discontinued if unanticipated settlement occurs, including settlements that deviate more than 3/8-inch from those indicated on the reviewed falsework Shop Drawing submittal. Concrete placement shall not resume until the Contractor provides corrective measures that are acceptable to the Engineer. Placing of concrete shall be discontinued if acceptable corrective measures are not provided to the Engineer prior to initial set of the concrete in the affected area. All unacceptable concrete shall be removed.

Where the maximum leg bad exceeds 30 kips, foundations for individual steel towers shall be designed and constructed to provide uniform settlement at each tower leg for all loading conditions.

Bents, Shoring Towers, Piles, Posts, and Caps:

Shop Drawings for falsework bents or shoring tower systems, including manufactured tower systems shall have plan, cross-section, and elevation view scale Shop Drawings showing all geometry. Show in the falsework Shop Drawing submittals the proximity of falsework to utilities or any nearby structures including underground structures. The ground elevation, cross-slopes, relation of stringers to one another, and dimensions to posts or piles shall be shown in the falsework Shop Drawing submittals. Column, pile, or tower heights shall be indicated. Member sizes, wall thickness and diameter of steel pipe columns or piles shall be shown in the falsework Shop Drawing submittals. Location of wedges, minimum bearing area and type of wedge material shall be identified in the falsework Shop Drawing submittals. Bracing size, location, material and all connections shall be described in the falsework Shop Drawing submittals.

The relationship of the falsework bents or shoring tower systems to the permanent Structure's pier and footing shall be shown. Load paths shall be as direct as possible. Loads shall be applied through the shear centers of all members to avoid torsion and buckling conditions. Where applied loads cause twisting, biaxial bending, or axial loading with bending, the affected members shall be designed for combined stresses and stability.

Posts or columns shall be constructed plumb with tops and bottoms carefully cut to provide full end bearing. Caps shall be installed at all bents supported by posts or piles unless Engineer reviewed falsework Shop Drawing submittals specifically permit otherwise. Caps shall be fastened to the piles or posts. The falsework shall be Capable of supporting nonuniform or localized loading without adverse effect. For example, the loading of cantilevered ends of stringers or caps shall not cause a condition of instability in the adjacent unloaded members.

Timber posts and piles shall be fastened to the caps and mudsills using through-bolted connections, drift pins, or other connections indicated on the Shop Drawings and reviewed by the Engineer. The minimum diameter of round timber posts shall be shown in the falsework Shop Drawing submittals. Timber caps and timber mudsills shall be checked for crushing from columns or piles under maximum load.

Steel posts and piles shall be welded or bolted to the caps and to the foundation. Steel members shall be checked for buckling, web yielding, and web crippling.

Wedges shall be used to permit formwork to be taken up and released uniformly. Wedges shall be oak. Cedar or other soft wood wedges or shims shall not be used anywhere in a falsework or forming system. Wedges shall be used at the top or the bottom of shores, but not at both top and bottom. After the final adjustment of the shore elevation is complete, the wedges shall be fastened securely to the sill or cap beam. The method of securely fastening wedges shall be included in the submittal. Only one set of wedges, with one optional block, shall be used at one location. Screw jacks, or other devices shown on the Shop Drawings for the Engineer's review, shall be used under arches to allow incremental release of the falsework.

Sand jacks may be used to support falsework and are used for falsework lowering only. Sand jacks shall be constructed of steel with snug fitting steel or concrete pistons. Sand jacks shall be filled with dry sand and the jack protected from moisture throughout its use. They shall be designed and installed in such a way to prevent the unintentional migration or loss of sand. All sand jacks shall be tested per Section 6-02.3(17)H.

When falsework is over or adjacent to roadways or railroads, all details of the falsework system which contribute to the horizontal stability and resistance to impact shall be installed at the time each element of the falsework is erected and shall remain in place until the falsework is removed. For other requirements see Section 6-02.3(17)D.

Transverse construction joints in the superstructure shall be supported by falsework at the joint location. The falsework shall be constructed in such a manner that subsequent pours shall not produce additional stresses in the concrete already in place.

Manufactured Shoring Tower Systems and Devices:

Manufactured proprietary shoring tower systems shall be identified in the falsework Shop Drawing submittal by make and model and safe working load capacity per leg. The safe working load for shoring tower systems shall be based upon a minimum 2-1/2 to 1 factor of safety.

The safe working load capacity, anticipated deflection (or settlement), make and model shall be identified in the falsework submittal for manufactured devices such as: single shores, overhang brackets, support bracket and jack assemblies, friction collars and clamps, hangers, saddles, and sand jacks. The safe working load for shop manufactured devices shall be based on a minimum ultimate strength safety factor of 2 to 1. The safe working load for field fabricated devices and all single shores shall be based on a minimum ultimate strength safety factor of 3 to 1.

The safe working load of all devices shall not be exceeded. The design loads shall be as defined by Section 6-02.3(17)B. The maximum allowable free end deflection of deck overhang brackets under working loads applied shall not exceed 3/16 inch regardless of the fact that the deflection may be compensated for by pre-cambering or of setting the elevations high. The Contractor shall comply with all manufacturer’s specifications; including those relating to bolt torque, placing washers under nuts and bolt heads, cleaning and oiling of parts, and the reuse of material. Devices which are deteriorated, bent, warped, or have poorly fitted connections or welds, shall not be installed.

Shoring tower or device capacity as shown in catalogs or brochures published by the manufacturer shall be considered as the maximum load which the shoring is able to safely support under ideal conditions. These maximum values shall be reduced for adverse loading conditions; such as horizontal loads, eccentricity due to unbalanced spans or placing sequence, and uneven foundation settlement.

Depending on load-carrying capacity, steel shoring systems are classified as pipe-frame systems, intermediate strength systems, and heavy-duty systems. The two types of pipe-frame shoring base frames in general use are the ladder type and the cross-braced type. In the ladder type, frame rigidity is provided by horizontal struts between the vertical legs, whereas in the cross-braced type rigidity is provided by diagonal cross-bracing between the legs.

Copies of catalog data and other technical data shall be submitted with the falsework Shop Drawing submittals to verify the load-carrying capacity, deflection, and manufacturers installation requirements of any manufactured product or device proposed for use. Upon request by the Engineer, the Contractor shall submit manufacturer certified test reports and results showing load capacity, deflection, test installation conditions, and identify associated components and hardware for shoring tower systems or other devices. In addition to manufacturer’s requirements, the criteria shown in the following sections for manufactured proprietary shoring tower systems and devices shall be complied with when preparing falsework Shop Drawing submittals, calculations, and installing these shoring tower systems and devices as falsework.

Alternative criteria and/or systems may be allowed if a written statement on the manufacturer’s letter head, signed by the shoring or device manufacturer (not signed by a material Supplier or the Contractor) is submitted to the Engineer for review and addresses the following:

(1) Identity of the specific Contract on which the alternative criteria and/or system applies;
(2) Description of the alternative criteria and/or system;
(3) Technical data and test reports;
(4) The conditions under which the particular alternative criteria may be followed; and
(5) That a design based on the alternative criteria shall not overstress or over deflect any shoring component or device nor reduce the required safety factor.

In any case where the falsework Shop Drawing submittals detail a manufactured product and the manufacturer’s safe working load, load versus deflection curves, factor of safety, and installation requirements cannot be found in any catalog, the Engineer may require load testing per Section 6-02.3(17)H to verify the safe working load and deflection characteristics.

For all tower systems, tower leg loads shall not exceed the limiting values under any loading condition or sequence. Frame extensions and any reduced capacity shall be shown in the falsework Shop Drawing submittals. Screw jacks shall fit tight in the leg assemblies without wobble. Screw jacks shall be plumb and straight. Shoring towers shall be installed plumb, and load distribution beams shall be arranged such that vertical loads are distributed to all legs for all successive concrete placements. There shall be no eccentric loads on shoring tower heads unless the heads have been designed for such loading. Shoring towers shall remain square or rectangular in plan view and shall not be skewed. There shall be no interchanging of parts from one manufactured shoring system to another. Bent or faulty components shall not be used.

For manufactured shoring towers that allow ganging of frames, the number of ganged frames shall be limited to one frame per opposing side of a tower, and the total number of legs per ganged tower shall not exceed eight legs. Ganged frames shall be installed per the manufacturer’s published standards using the manufacturer’s components. Other gang arrangements shall not be used.

For manufactured steel shoring tower systems, the Contractor shall have bracing designed and installed for horizontal loads and falsework overturning per Section 6-02.3(17)B. Minimum bracing criteria and allowable leg loads are described in the following paragraphs.

All shoring tower systems and bracing shall be thoroughly inspected by the Contractor for plumb vertical support members, secure connections, and straight bracing members immediately prior to, at intervals during, and immediately after every concrete placement. For manufactured shoring tower systems, the maximum allowable deviation from the vertical is 1/8-inch in 3 feet. If this tolerance is exceeded, concrete shall not be placed until adjustments have brought the shoring towers within the acceptable tolerance.

Cross-Braced Type Base Frames:

The maximum allowable load per leg for cross-braced type base frame shoring is limited by the height of the extension frame and the type of screw jack (swivel or fixed head) used at the top of the frame. The maximum load on one leg of a frame shall not exceed four times the load on the other leg under any given loading condition or sequence. The maximum load on one of the two frames making up a tower shall not exceed four times the load on the opposite frame under any given loading condition or sequence. If swivel-head screw jacks are used, the allowable leg loads shall not exceed that shown in the following table:

Maximum Allowable Leg Load in Pounds				
Extension Frame Height	**2'-0"**	**3'-0"**	**4'-0"**	**5'-0"**
Screw height 12" or less	11,000	11,000	10,000	9,400
Screw height exceeds 12"	8,200	8,200	8,000	7,800

If fixed-head screw jacks are used at the top of the extension frame, the maximum allowable load per leg shall be 11,000 pounds for all extension frame heights up to five feet with screw jack height extensions of 12 inches or less. Fixed-head screw jacks exceeding 12 inches shall use the values in the table above. Screw jack extensions shall not exceed the manufacturer's published recommendations. Extension frames shall be braced. Side cross-braces are required for extension heights up to 2 feet 0 inches. Both side and end cross-braces are required from over 2 feet 0 inches to 5 feet 0 inches extension heights.

Supplemental bracing shall be installed on shoring towers 20 feet or more in height and shall connect rows of towers to each other so rows of frames are continuously cross-braced in one plane. Supplemental bracing shall be installed as follows:

1. In the transverse direction (the direction parallel to the frame), one horizontal brace and one diagonal brace shall be attached to each tower face, for every three frames of shoring height, including an extension frame if used. The lowest horizontal brace shall be located near the top of the third tower frame, and any additional horizontal braces spaced no farther than three frames apart. The diagonal braces shall be located on opposite tower faces, and shall run in opposite directions across the plane of the tower row.
2. In the longitudinal direction (the direction perpendicular to the frames), when shoring height is four frames or more, a horizontal brace shall be installed on one face of each tower, with the lowest brace located no higher than the top of the fourth frame and any additional horizontal braces spaced no farther than four frames apart. When shoring height is six frames or more, diagonal cross-bracing shall be installed in the longitudinal direction similar to the transverse direction.
3. When roadway grade, soffit profile, or superelevation exceeds 4 percent slope for any height of shoring tower, a continuous brace parallel to the slope shall be attached to each frame extension or screw jack of the tower within 6 inches of the top. These braces shall be in addition to bracing previously described.

The bracing shall be fastened securely to each frame leg and shall be located within 6 inches of the frame member intersections. The ends of diagonal braces shall not be attached to shoring frames at locations where towers have little or no load. Diagonal brace ends shall be attached to tower frames near the top and bottom at locations where significant gravity load is maintained throughout all construction sequences, such as directly below box girder outside webs, thus precluding lift-off due to the vertical component of the brace reaction. Supplemental bracing shall be shown in the falsework Shop Drawing submittal. The connection details, including the method of connection and exact location of the connecting devices, shall be in accordance with the manufacturer's recommendations and shall be shown in the falsework Shop Drawing submittals.

Ladder Type Base Frames:

Ladder type base frame shoring shall be limited to the following maximum loads and conditions, regardless of any conflicting information which may be found in manufacturer's catalogs or brochures:

1) If the shoring system consists of a single tier of braced base frames, leg loads shall not exceed 10,000 pounds;
2) If the shoring system consists of two or three tiers of base frames, leg loads shall not exceed 7,500 pounds;
3) If an extension staff is used, the maximum allowable leg load shall be reduced to 6,000 pounds; and
4) The maximum load on one leg of a frame shall not exceed four times the load on the other leg under any given loading condition or sequence. The maximum load on one of the two frames making up a tower shall not exceed four times the load on the opposite frame under any given loading condition or sequence.

Maximum allowable leg loads as shown above shall apply when fixed-head screw jacks are used, or when swivel-head jacks are used at either the top or bottom of the tower. A screw jack extension shall not exceed 12 inches. Swivel-head screw jacks shall not be used at both the top and bottom of ladder-type frames. For any combination of ladder-type base frames or base frames with staff extensions, the total height of the shoring shall not exceed 20 feet, including screw jack extensions.

When roadway grade, soffit profile, or superelevation exceeds 4 percent slope for heights of shoring towers 20 feet or less, a continuous brace parallel to the slope shall be attached to each staff extension or screw jack of the tower within 6 inches of the top. These braces shall be attached per conditions described previously for cross-braced frames.

Intermediate Strength Shoring:

Steel shoring, consisting of cross-braced tubular members Capable of carrying up to 25 kips per tower leg, is considered intermediate strength shoring. The use of a 25-kip type falsework shoring system shall meet the following conditions and limitations:

(1) If swivel-head screw jacks are used at either the top or bottom of the tower, the maximum allowable load shall be reduced to 20 kips per tower leg;
(2) The screw-jack adjustment shall not exceed 14 inches;
(3) Extension frames shall be braced. Side cross-braces are required for all extension-frame heights. In addition, end cross-braces (braces across the face of the extension frame) shall be provided for extension frame heights of 3 feet 0 inches or more;
(4) The maximum load on one leg of a frame, or on one frame of a tower, shall not exceed four times the load on the opposite leg or frame under any given loading condition or sequence;
(5) Shoring towers 20 feet or more in height shall have supplemental bracing installed in accordance with the criteria for bracing “Cross-braced Type Base Frames”, except that no supplemental bracing will be required in the longitudinal direction (the direction perpendicular to the frame); and
(6) When roadway grade, soffit profile, or superelevation exceeds 4 percent slope for any height of shoring tower a continuous brace parallel to the slope shall be attached to each frame extension or screw jack of the tower within 6 inches of the top. These braces shall be in addition to bracing required in item 5.

The use of 25-kip shoring, when designed and erected in conformance with the above criteria, is acceptable for tower heights up to five frames plus a fully-extended extension frame plus the maximum allowable screw-jack adjustment. For any proposed use exceeding this limiting height, the Contractor shall submit a statement signed by the shoring manufacturer covering the specific installation. The statement shall provide assurance that the shoring shall carry the loads to be imposed without overstressing any shoring component or reducing the required safety factor.

Heavy-Duty Shoring Systems:

Shoring Capable of carrying up to 100 kips per tower leg is considered heavy duty shoring. The following criteria applies to these systems.

If tower legs, including any extension unit, are utilized as single-post shores braced in one direction only, the shores shall be analyzed as individual steel columns.

If the total height of the shoring does not exceed the height of a single tower unit, including any extension unit, and if both the base and extension units are fully braced in both directions in accordance with the manufacturer’s recommendations, individual tower legs may be considered as Capable of carrying the safe working load recommended by the manufacturer without regard to the load on adjacent legs.

If the shoring consists of two or more units stacked one above the other, either with or without an extension unit, the differential leg loading within a given tower unit shall not exceed the following limitations:

DIFFERENTIAL LEG LOADING	
Maximum load on any leg in the tower unit	**Maximum to Minimum load ratio**
10 kips or less	10 to 1
10 kips to 50 kips	6 to 1
50 kips to 75 kips	5 to 1
75 kips or more	4 to 1

A complete stress analysis of steel beams used as continuous caps over two or more tower units shall be performed to determine the effect of continuity on tower leg loads. Resulting moment shear shall be added to or subtracted from the simple beam reaction to obtain the actual leg load and may produce a significant load differential.

Heavy-duty shoring shall be diagonally braced or otherwise externally supported at the top unless the towers are stable against overturning as defined in Section 6-02.3(17)B. When designing external bracing, including cable bracing, attention shall be given to the bracing connection to the falsework. Connections shall be designed to transfer horizontal and vertical forces from the falsework to the bracing system without overstressing any tower component. All external bracing, attachment locations, and connection details shall be shown in the falsework Shop Drawing submittals.

6-02.3(17)F STRINGERS, BEAMS, JOISTS, ROADWAY SLAB SUPPORT, AND DECK OVERHANGS

All stringers, beams, joists, and roadway slab support shall be designed for the design loads, deflections, and allowable stresses described in the preceding Sections 6-02.3(17)B, 6-02.3(17)C, and 6-02.3(17)D and for the following conditions.

At points of support, stringers, beams, joists, and trusses shall be restrained against rotation about their longitudinal axis. The effect of biaxial bending shall be investigated in all cases where falsework beams are not set plumb and the structure cross-slope exceeds 3 percent.

For box girder and T-beam bridges, the centerline of falsework beams or stringers shall be located within 2 feet of the bridge girder stems and preferably directly under the stems or webs. Stringers supporting formwork for concrete box girder and T-beam slab overhangs shall be stiff enough so that the differential deflection due to the roadway slab pour is no more than 3/16 inch between the outside edge of the roadway slab and the exterior web even if camber strips can compensate for the deflection.

Friction shall not be relied upon for lateral stability of beams or stringers. If the compression flange of a beam is not laterally restrained, the allowable bending stress shall be reduced to prevent flange buckling. If flange restraint is provided and since it is impossible to predict the direction in which a compression flange buckles, positive restraint shall be provided in both directions. Flange restraint shall be designed for a minimum load of two percent of the calculated compression force in the beam flange at the point under consideration.

Camber strips shall be used to compensate for falsework take-up and deflection, vertical alignment, and the anticipated structure dead load deflection shown in the camber diagram on the Drawings. Camber is the adjustment to the profile of a load-supporting beam or stringer so that the completed structure shall have the lines and grades shown on the Drawings. The dead load camber diagram shown on the Drawings is the predicted Structure dead load deflection due to self weight. This dead load camber shall be increased by:

(1) Amount of anticipated falsework take up;
(2) Anticipated deflection of the falsework beam or stringer under the actual load imposed; and
(3) Any vertical curve compensation.

Camber strips shall be fastened by nailing to the top of wood members, or by clamping or banding in the case of steel members. Camber strips shall have sufficient contact bearing area to prevent crushing under total load. As a general rule, camber strips are not required unless the total camber adjustment exceeds 1/4-inch for exterior falsework stringers and 1/2-inch for interior stringers.

On concrete box girder structures, the forms supporting the roadway slab shall rest on ledgers or similar supports and shall not be supported from the bottom slab except as the following provides. The form supports shall be fastened within 18 inches of the top of the web walls, producing a clear span between web walls. The roadway slab forms may be supported or posted from the bottom slab if all the following conditions are met:

1. Permanent access, shown on the Drawings, is provided to the cells;
2. Centerline to centerline distance between web walls is greater than 10 feet;
3. Falsework stringers designed for total load, stresses and deflections per Sections 6-02.3(17)B and 6-02.3(17)C are located directly below each row of posts;
4. Posts have adequate lateral restraint; and
5. All forms (including the roadway deck forms), posts, and bracing are completely removed.

The falsework and forms on concrete box girder structures supporting a sloping web and deck overhang shall consist of a lateral support system. The support system shall be designed to resist all rotational forces acting on the stem, including those caused by the placement of deck slab concrete, roadway deck formwork weight, finishing machine, and other live loads. Stem reinforcing steel shall not be stressed by the construction of the roadway deck slab placement. Overhang brackets shall not be used for the support of roadway slab forms from sloping web concrete box girder bridges.

Deck slab forms between girders or webs shall be constructed such that there is no differential settlement relative to the girders. The support systems for form panels supporting concrete deck slabs and overhangs on girder bridges, such as steel plate girders and prestressed girders, shall be designed as falsework. Falsework supporting deck slabs and overhangs on girder bridges shall be supported directly by the girders so that there shall be no differential settlement between the girders and the deck forms during placement of deck concrete.

6-02.3(17)G BRACING

All falsework bracing systems shall be designed to resist the horizontal design load in all directions with the falsework in either the loaded or unloaded condition. All bracing, connection details, specific locations of connections, and hardware used shall be shown in the falsework Shop Drawing submittals. Falsework diagonal bracing shall be thoroughly analyzed with particular attention given to the connections. The allowable stresses in the diagonal braces may be controlled by the joint strength or the compression stability of the diagonal. Timber bracing for timber falsework bents shall have connections designed per Section 6-02.3(17)J. Any damaged cross-bracing, such as split timber members, shall be replaced. Steel strapping shall avoid making sharp angles or right-angle bends. A means of preventing accidental loss of tension shall be provided for steel strapping. See Sections 6-02.3(17)B, 6-02.3(17)C and 6-02.3(17)D for design loads and allowable stresses.

Bracing shall not be attached to concrete traffic barrier, guardrail posts, or guardrail.

To prevent falsework beam or stringer compression flange buckling, cross-bracing members and connections shall be designed to carry tension as well as compression. All components, connection details and specific locations shall be shown in the falsework Shop Drawing submittals. Bracing, blocking, struts, and ties required for positive lateral restraint of beam flanges shall be installed at right angles to the beam in plan view. If possible, bracing in adjacent bays shall be set in the same transverse plane. However, if because of skew or other considerations, it is necessary to offset the bracing in adjacent bays, the offset distance shall not exceed twice the depth of the beam.

All falsework and bracing shall be inspected by the Contractor for plumbness of vertical support members, secure connections, tight cables, and straight bracing members immediately prior to, during, and immediately after every concrete placement.

Bracing shall be provided to withstand all imposed loads during erection of the falsework and all phases of construction for falsework adjacent to any roadway, sidewalk, or railroad track which is open to the public. All details of the falsework system that contribute to horizontal stability and resistance to impact, including the bolts in bracing, shall be installed at the time each element of the falsework is erected and shall remain in place until the falsework is removed. The falsework Shop Drawing submittals shall show provisions for any supplemental bracing or methods to be used to conform to this requirement during each phase of erection and removal. Wind loads shall be included in the design of such bracing or methods. Loads, connections, and materials for falsework adjacent to roadways, shall also be in accordance with Section 6-02.3(17)D.

Cable or Tension Bracing Systems:

All elements of the bracing system shall be shown in the falsework Shop Drawing submittals when cables, wire rope, steel rod, or other types of tension bracing members are used as external bracing to resist horizontal forces, or are used as temporary bracing to support bents while falsework is being erected or removed adjacent to traffic. Bracing shall not be attached to concrete traffic barrier, guardrail posts, or guardrail. Any damaged bracing, such as frayed and kinked guying systems, shall be immediately replaced. Wire rope shall not make a sharp angle bend or a right-angle bend. A means of preventing accidental loss of tension in the wire rope shall be provided. The following information shall be submitted to the Engineer for review:

1) Cable diameter, rod, or tension member size, and allowable working load;
2) Location and method of attaching the cable, rod, or tension member to the falsework. The connecting device shall be designed to transfer both horizontal and vertical forces to the cable without overstressing any falsework component;
3) The type of cable connectors or fastening devices (such as U-bolt clips, plate clamps, etc.) to be used and the efficiency factor for each type. If cables are to be spliced, the splicing method shall be shown;
4) Method of tightening cables, rods, or tension members after installation if tightening is necessary to ensure their effectiveness. Method of preventing accidental loosening;
5) Anchorage details, including the size and weight of concrete anchor blocks, the assumed coefficient of friction for surface anchorages, and the assumed lateral soil bearing capacity for buried anchorages;
6) Method of pre-stretching or preloading cable or tension members; and
7) Determination of the potential stretch or elongation of the tension member under the design load and if the resulting lateral deflection causes excessive secondary stresses in the falsework.

Copies of manufacturer’s catalog or brochure showing technical data pertaining to the type of cable to be used shall be furnished with the falsework Shop Drawing submittal. Technical data shall include the cable diameter, the number of strands and the number of wires per strand, ultimate breaking strength or recommended safe working strength, and any other information as may be needed to identify the cable.

In the absence of sufficient technical data to identify the cable, or if it is old and obviously worn, the Contractor shall perform cable breaking tests to establish the safe working load for each reel of cable furnished. For static guy cable the minimum factor of safety shall be 3 to 1. The Contractor shall notify the Engineer at least 2 Working Days in advance for witnessing these tests.

When cable bracing is used to prevent the overturning of heavy-duty shoring, attention shall be given to the connections by which forces are transferred from the shoring to the cables. Cable restraint shall be designed to act through the cap system to prevent the inadvertent application of forces which the shoring is not designed to withstand. Cables shall not be attached to any tower component.

Cable splices made by lapping and clipping with “Crosby” type clamps shall not be used. Other splicing methods may be used. Cable strength shall be verified by a load test at each location where the cable is spliced.

When cables are used as external bracing to resist overturning of a falsework system, the horizontal load to be carried by the cables shall be calculated as follows:

(1) When used with heavy-duty shoring systems, cables shall be designed to resist the difference between 1.25 times the total overturning moment and the resistance to overturning provided by the individual falsework towers;
(2) When used with pipe-frame shoring systems where supplemental bracing is required, cables shall be designed to resist the difference between 1.25 times the total overturning moment and the resistance to overturning provided by the shoring system as a whole; and
(3) When used as external bracing to prevent overturning of all other types of falsework, including temporary support during erection and removal of falsework at traffic openings, cables shall be designed to resist 1.25 times the total overturning moment.

The maximum allowable cable design load shall be determined using the following criteria and the tables immediately following:

1. If the cable is new or if the cable is in uniformly good condition, and if the cable can be identified by reference to a manufacturer’s catalog or other technical publication, then the allowable load shall be the ultimate strength of the cable as specified by the manufacturer, multiplied by the efficiency of the cable connector ("Connector Efficiency"), and divided by a safety factor of 3 (i.e., safe working load = breaking strength x connector efficiency/safety factor.);

2. If the cable is used but is still in serviceable condition, or the cable is new or nearly new but cannot be found in a manufacturer's catalog, then the Contractor shall perform load breaking tests. In this case, the cable design load shall not exceed the breaking strength determined by the load test, multiplied by the "Connector Efficiency" factor, and divided by a safety factor of 3; and
3. If the cable is used and is still in serviceable condition, or the cable is a new or nearly new cable which cannot be identified, and if load breaking tests are not performed, then the cable design load shall not exceed the safe working load ("Safe Load") shown in the Wire Rope Capacities table multiplied by the cable "Connector Efficiency".

Cable connectors shall be designed in accordance with criteria shown in the following tables "Efficiency of Wire Rope Connections" and "Applying Wire Rope Clips". Cable safe working loads are provided in table "Wire Rope Capacities".

Efficiency of Wire Rope Connections (As compared to Safe Loads on Wire Rope)	
Type of Connection	**Connector Efficiency**
Wire Rope	100%
Sockets – Zinc Type	100%
Wedge Sockets	70%
Clips – Crosby Type with Thimble	80%
Knot and Clip (Contractors Knot)	50%
Plate Clamp-Three Bolt Type with Thimble	80%
Spliced Eye and Thimble:	
1/4" and smaller	100%
3/8" to 3/4"	95%
7/8" to 1"	88%
1-1/8" to 1-1/2"	82%
1-5/8" to 2"	75%
2-1/8" and larger	70%

WIRE ROPE CAPACITIES Safe Load in Pounds for New Plow Steel Hoisting Rope 6 Strands of 19 Wires, Hemp Center (Safety Factor of 6)		
Diameter Inches	**Weight Lbs/Ft**	**Safe Load Lbs**
1/4	0.10	1,050
5/16	0.16	1,500
3/8	0.23	2,250
7/16	0.31	3,070
1/2	0.40	4,030
9/16	0.51	4,840
5/8	0.63	6,330
3/4	0.95	7,930
7/8	1.29	10,730
1	1.60	15,000
1-1/8	2.03	18,600
1-1/4	2.50	23,000
1-3/8	3.03	25,900
1-1/2	3.60	30,700
1-5/8	4.23	35,700
1-3/4	4.90	41,300

Applying Wire Rope Clips:

The only correct method of attaching U-bolt wire rope clips to rope ends is to place the base (saddle) of the clip against the live end of the rope, while the "U" of the bolt presses against the dead end.

The clips are usually spaced about six rope diameters apart to give adequate holding power. A wire-rope thimble shall be used in the loop eye to prevent kinking when wire rope clips are used. The correct number of clips for safe application, and spacing distances, are as follows:

Number of Clips and Spacing for Safe Application			
	Number of Clips		
Improved Plow Steel Rope Diameter (Inches)	Drop Forged	Other Material	Min. Spacing (Inches)
3/8	2	3	3
½	3	4	3-1/2
5/8	3	4	4
¾	4	5	4-1/2
7/8	4	5	5-1/4
1	5	6	6
1-1/8	6	6	6-3/4
1-1/4	6	7	7-1/2
1-3/8	7	7	8-1/4
1-1/2	7	8	9

Anchor Blocks:

Concrete anchor blocks and connections used to resist forces from external bracing shall be shown in the falsework Shop Drawing submittal. Concrete anchor blocks shall be proportioned to resist both sliding and overturning. When designing anchor block stability, the weight of the anchor block shall be reduced by the vertical component of the cable or brace tension to obtain the net or effective weight to be used in the anchorage computations. The coefficient of friction assumed in the design shall not exceed the following:

Setting	Friction Coefficient
Anchor block set on sand	0.40
Anchor block set on clay	0.50
Anchor block set on gravel	0.60
Anchor block set on pavement	0.60

Note: Multiply the friction coefficient by 0.67 if it is likely the supporting material is wet or shall become wet during the construction period.

The method of connecting the cable or brace to the anchor block is part of the anchor block design. The connection shall be designed to resist both horizontal and vertical forces.

Temporary Bracing for Bridge Girders:

Bridge girders (such as steel plate girders and prestressed girders) shall be braced and tied to resist forces applied during construction that would cause rotation or torsion in the girders. Falsework support brackets or braces shall not be welded to structural steel members or reinforcing steel.

On prestressed girder spans, the Contractor shall install cross-bracing between girders at each end and midspan to prevent lateral movement or rotation. This bracing shall be placed immediately after erection of the girders. The bracing shall not be removed until the diaphragms or the deck have been placed and cured for a minimum of 24 hours.

When deck overhang or the distance from the centerline of the exterior girder, or outside girder of a staged construction, to the near edge of the roadway slab on a prestressed girder span exceeds the distances listed in the table that follows, the Contractor shall provide extra bracing for the exterior girder at the midpoint between diaphragms (or at more frequent intervals). This bracing shall include:

(1) a cross-tie connecting the top flange of each exterior girder with its counterpart on the other side, and
(2) braces between the bottom flanges and top flanges of all girders.

Girder Series	Distance in Inches
W42G	30
W50G	42
W58G	63
W74G	66

If a concrete finishing machine is supported at the outside edge of the slab, the Contractor shall account for its added weight in the design of bracing.

Roadway deck forming systems may require bracing or ties between girders for the girder to adequately support the form loading. When braces, struts, or ties are required, they shall be designed and detailed by the Contractor in accordance with Section 6-02.3(16)A and shall be shown in the falsework/formwork Shop Drawing submittal to the Engineer for review. These braces, struts, and ties shall be furnished and installed by the Contractor at no additional cost to the Owner.

6-02.3(17)H TESTING FALSEWORK DEVICES

The Contractor shall establish the load capacity and deflection (or settlement) of all friction collars and clamps, brackets, hangers, saddles, sand jacks, and similar devices. The Contractor shall utilize an independent testing laboratory accredited in accordance with ASTM E 1595 and approved by the Engineer to establish these values. Laboratory tests shall use the same materials and design that shall be used on the project. Test loads shall be applied to the device in the same manner that the device is to experience loading on the project. Any bolts or threaded rods used with the device shall be identified as to diameter, length, type, grade, and torque. Any wedges, blocks, or shims used with the device on the project shall also be tested with the device. Any adjustable jack system used as a part of a device shall be tested with the device and shall have its maximum safe working extended height identified. Devices shall not be tested in contact with the permanent structure. Independent members with the same properties as the permanent structure shall be used to test device connections.

At least fourteen (14) days prior to the test, the Contractor shall submit a test procedure and scale drawing for the Engineer's review showing how the device is to be tested and how data is to be collected. The Contractor shall provide the Engineer at least 2 Working Days advance notice for an opportunity to witness these tests.

In addition to the requirements of Section 1-06.5, the approved independent testing laboratory identified in this Specification Section shall provide a certified test report which shall be signed and dated. The test report shall:

1. clearly identify the device tested including trademarks and model numbers;
2. identify all parts and materials used, including grade of steel, or lumber, member section dimensions;
3. show location, size, and the maximum tested extended height of any adjustable jacks;
4. indicate condition of materials used in the device;
5. indicate the size, length and location of all welds; and
6. indicate how much torque was used with all bolts and threaded rods.

The report shall also describe:

a. how the device was tested,
b. report the results of the test,
c. provide a scale drawing of the device showing the location(s) of where deflections or settlements were measured, and
d. show where load was applied.

Deflections or settlements shall be measured at each load increment and the results shall be clearly graphed and labeled. Prior to installation of falsework devices named in this Specification Section, the Contractor shall submit the certified test reports to the Engineer for review.

The safe working load for shop manufactured devices named in this section shall be derived by dividing the ultimate strength by a safety factor of 2.0. The safe working load for field fabricated or field modified devices (including the use of timber blocks or wedges with the device) shall be determined by dividing the ultimate strength by a safety factor of 3.0. Working load shall include weights of all successive concrete placements, falsework, forms, all load transfer that takes place during post-tensioning, and any live loads; such as workers, roadway finishing machines, and concrete delivery systems. The maximum allowable free end deflection of deck overhang brackets with combined dead and live working loads applied shall be 3/16 inch even though deflection may be compensated for by pre-cambering or setting the elevations high. The Contractor shall comply with all manufacturer's specifications, including those relating to bolt torque, cleaning and oiling of parts, and the reuse of material. Devices that are deteriorated, bent, warped or have poorly fitted connections or welds, shall not be installed.

6-02.3(17)I FORMWORK ACCESSORIES

Formwork accessories such as form ties, form anchors, form hangers, anchoring inserts, and similar hardware shall be specifically identified in the formwork Shop Drawings. The identification shall include the name and size of the hardware, the manufacturer, the safe working load, and the factor of safety. The grade of steel shall also be indicated for threaded rods, coil rods, and similar hardware. Wire form ties taper ties and welding or clamping formwork accessories to Drawings reinforcing steel shall not be used. Driven types of anchorages for fastening forms or form supports to concrete, and Contractor fabricated "J" hooks shall not be used. Field drilling of holes in prestressed girders is not allowed.

The following table from ACI 347R-88 provides minimum safety factors for formwork accessories. The hardware proposed shall meet these minimum ultimate strength requirements or the manufacturer's minimum requirements, whichever provides the greater factor of safety. The Contractor shall attach copies of the manufacturer's catalog cuts and/or test data of hardware proposed, to the formwork Shop Drawings and submit the falsework and formwork Shop Drawings and calculations for review per Section 6-02.3(16). In situations where catalog cuts and/or test data are not available, testing shall be performed in accordance with Section 6-02.3(17)H.

MINIMUM SAFETY FACTORS OF FORMWORK ACCESSORIES[1]		
Accessory	**Safety Factor**	**Type of Construction**
Form tie	2.0	All applications
Form anchor	2.0	Formwork supporting form weight and concrete pressures only
Form anchor	3.0	Formwork supporting weights of forms, concrete, construction live loads, and impact
Form hangers	2.0	All applications
Anchoring inserts	2.0	Placed in previous opposing concrete placement to act as an anchor for form tie

[1]Safety factors are based on ultimate strength of the formwork accessory.

The bearing area of external holding devices shall be adequate to prevent excessive bearing stress on form lumber. Form ties and form hangers shall be arranged symmetrically on the supporting members to minimize twisting or rotation of the members. Form tie elongation shall not exceed the allowable deflection of the wale or member that it supports. Inserts, bolts, coil rods, and other fasteners shall be analyzed and designed for appropriately combined bending, shear, torsion, and tension stresses. The formwork shall not be attached to Contract Drawing rebar or rebar cages. However, the Contractor may install additional reinforcing steel for formwork anchorage.

Frictional resistance shall not be considered as contributing to the stability of any connection or connecting device, except those designed as friction connectors such as U-bolt friction-type connectors.

Form anchors and anchoring inserts shall be designed considering concrete strength at time of loading, available embedment, location in the member, and any other factors affecting their working strength, and shall be installed in concrete per the manufacturer's published requirements. Form anchors and anchoring inserts embedded in previous concrete placements shall not be loaded until the concrete has reached the required design strength. The required design strength of concrete for loading of an anchor shall be shown in the formwork Shop Drawing if it is assumed that the anchor is to be loaded before the concrete has reached its 28 day strength.

Installation of permanent concrete inserts, such as form ties hangers, or embedded anchor assemblies, shall permit removal of all metal to at least 1/2-inch below the concrete surface. Holes shall be patched in accordance with Section 6-02.3(14). During removal of the outer unit, the bond between the concrete and the inner unit or rod shall not be broken.

6-02.3(17)J TIMBER CONNECTIONS

Timber connections shall be designed in accordance with the methods, stresses, and loads allowed in the Timber Construction Manual, Third Edition by the American Institute of Timber Construction (AITC). Timber falsework and formwork connections shall be designed using wet condition stresses for all installations West of the Cascade Range crest line and by criteria provided in the following sections. Frictional resistance shall not be considered as contributing to the stability of any timber connection.

Bolted Connections:

Tabulated values in the AITC Timber Construction Manual-Third Edition are based on square posts. For a round post or pile, the main member thickness shall be the side of a square post having the same cross-sectional area as the round post used.

The AITC Table 6.20 for Douglas Fir-Larch bolt Group 3 and for Hem-Fir bolt Group 8 show design values for bolts to be used when the load is applied either parallel or perpendicular to the direction of the wood grain. When the load is applied at an angle to the grain, as is the case with falsework bracing, the design value for the main member shall be obtained from the Hankinson formula shown in the AITC manual.

Design values in the AITC Table 6.20 apply only to three member joints (bolt in double-shear) in which the side members are each 1/2 the thickness of the main member. This joint configuration is not typical of bridge falsework where side members are usually much smaller than main members. For two member joints (single shear bolt condition), the AITC Table 6.20 values shall be adjusted by a single shear load factor as follows:

1. 0.75 for installations East of the Cascade Range crest line, except as shown in following item 3;
2. 0.50 for installations West of the Cascade Range crest line; and
3. 0.50 for load acting at an angle to the bolt axis, as is the case with longitudinal bracing when falsework bents are skewed.

Except for connections in falsework adjacent to or over railroads or roadways, threaded rods and coil rods may be used in place of bolts of the same diameter with no reduction in the tabulated values. At openings for roadways and railroads, all connections shall be bolted using 5/8-inch diameter or larger through bolts.

Bolt holes shall be a minimum 1/32-inch to a maximum 1/8-inch larger than the bolt diameter. A washer not less than a standard cut washer shall be installed between the wood and the bolt head and between the wood and the nut to distribute the bearing stress under the bolt head and nut and to avoid crushing the fibers. In lieu of standard cut washers, metal plates or straps with dimensions at least equal to that of a standard cut washer may be substituted.

When steel bars or shapes are used as diagonal bracing, the tabulated design values shown in AITC Table 6.20 for the main members loaded parallel to grain (P value) are increased 75 percent for joints made with bolts 1/2-inch or less in diameter, 25 percent for joints made with bolts 1-1/2-inches in diameter, and proportionally for intermediate diameters. No increase in the tabulated values is allowed for perpendicular-to-grain loading (Q value).

Clearance requirements for end, edge, and bolt spacing distance shall be as shown in the following. All distances are measured from the end or side of the wood member to the center of the bolt hole. For members which are subject to load reversals, the larger controlling distances shall be used for design. For parallel-to-grain loading, the minimum distances for full design load:

(1) In tension, minimum end distance shall be 7 times the bolt diameter;
(2) In compression, minimum end distance shall be 4 times the bolt diameter; and
(3) In tension or compression, the minimum edge distance shall be 1.5 times the bolt diameter.

For perpendicular-to-grain loading, the minimum distance for full design load:

a. Minimum end distance shall be 4 times the bolt diameter;
b. Edge distance toward which the load is acting shall be at least 4 times the bolt diameter; and
c. Distance on the opposite edge shall be at least 1.5 bolt diameters.

Minimum clearance (spacing) between adjacent bolts in a row shall be 4 times the bolt diameter, measured center-to-center of the bolt holes.

When more than two bolts are used in a line parallel to the axis of the side member, additional requirements shall be followed as shown in the AITC manual.

Lag Screw Connections:

Design values for lag screws subject to withdrawal loading are found in AITC Table 6.27. Values for wood having a specific gravity of 0.51 for Douglas Fir-Larch or 0.42 for Hem-Fir shall be assumed when using the table. The withdrawal values are in pounds per inch of penetration of the threaded part of the lag screw into the side grain of the member holding the point, with the axis of the screw perpendicular to that member. The maximum load on a given screw shall not exceed the allowable tensile strength of the screw at the root section.

AITC recommends against subjecting lag screws to end-grain withdrawal loading. However, if this condition cannot be avoided, the design value shall be 75 percent of the corresponding value for withdrawal from the side grain.

Values in the Group II wood species column shall be used for Douglas Fir-Larch and the Group III wood species column shall be used for Hem-Fir. When the load is applied at an angle to the grain, as is the case with falsework bracing, the design value shall be obtained from the Hankinson formula shown in the AITC manual.

When lag screws are subjected to a combined lateral and withdrawal loading, as would be the case with longitudinal bracing when the falsework bents are skewed, the effect of the lateral and withdrawal forces shall be determined separately. The withdrawal component of the applied load shall not exceed the allowable value in withdrawal. The lateral component of the applied load shall not exceed the allowable lateral load value.

Lag screws shall be inserted in lead holes as follows:

1. The clearance hole for the shank shall have the same diameter as the shank, and the same depth of penetration as the length of unthreaded shank;
2. The lead hole for the threaded portion shall have a diameter equal to 60 to 75 percent of the shank diameter and a length equal to at least the length of the threaded portion. The larger percentile figure in each range shall apply to screws of the greater diameters used in Group II wood species;
3. The threaded portion of the screw shall be inserted in its lead hole by turning with a wrench, not by driving with a hammer; and
4. To facilitate insertion, soap or other lubricant shall be used on the screws or in the lead hole.

Drift Pin and Drift Bolt Connections:

When drift pins or drift bolts are used, the required length and penetration shall be determined using the following criteria:

The lateral load-carrying capacity of drift pins and drift bolts driven into the side grain of a wood member shall be limited to 75 percent of the design values for a common bolt of the same diameter and length in the main member. For drift pin connections, the pin penetration into the connected members shall be increased to compensate for the absence of a bolthead and nut. For drift bolts or pins driven into the end grain of a member, the lateral load-carrying capacity shall be limited to 60 percent of the allowable side grain load (perpendicular to grain value) for an equal diameter bolt with nut. To develop this allowable load the drift bolt or pin shall penetrate at least 12 diameters into the end grain. To fully develop the allowable load of the drift bolts or pins, they shall be driven into pre-drilled holes, 1/16-inch less in diameter than the drift pin or bolt diameter.

The criteria shown in the AITC Timber Construction Manual-Third Edition shall apply to drift bolt or pin connection allowable loads for the following conditions:

1) Withdrawal resistance; and
2) When there are more than two drift bolts or pins in a joint, allowable loads shall be further reduced by applying applicable modification factors shown in the AITC Table 6.3.

Nailed and Spiked Joints:

Joints using nails or spikes shall conform to the provisions of AITC. For side grain withdrawal, the values in AITC Table 6.35 for wood having a specific gravity of 0.51 for Douglas Fir-Larch and a specific gravity of 0.42 for Hem-Fir shall be used. End grain withdrawal shall not be used. For lateral loading, the values in AITC Table 6.36 for wood species Group II for Douglas Fir-Larch and wood species Group III for Hem-Fir shall be used. Diameters listed in the tables apply to fasteners before application of any protective coating.

When more than one nail or spike is used in a joint, the total design value for the joint in withdrawal or lateral resistance shall be the sum of the design values for the individual nails or spikes.

The tabulated design values for lateral loads are valid only when the nail penetrates into the main member at least 11 diameters for Douglas Fir-Larch and 13 diameters for Hem-Fir. Note that the values are maximum values for the type and size of fastener shown. The tabulated values shall not be increased even if the actual penetration is exceeded.

When main member penetration is less than 11 diameters for Douglas Fir-Larch and 13 diameters for Hem-Fir, the design value shall be determined by straight-line interpolation between zero and the tabulated load, except that penetration shall not be less than 1/3 of that specified.

Double-headed or duplex nails used in falsework and formwork construction are shorter than common wire nails or box nails of the same penny weight. They have less penetration into the main member and therefor their load-carrying capacity shall be adjusted accordingly.

Nail and spike minimum spacing in timber connections shall be as follows:

1. The average center-to-center distance between adjacent nails, measured in any direction, shall not be less than the required penetration into the main member for the size of nail being used; and
2. The minimum end distance in the side member, and the minimum edge distance in both the side member and the main member, shall not be less than 1/2 of the required penetration.

Allowable values for withdrawal and lateral load resistance are reduced when toe nails are used in accordance with the following:

a. For withdrawal loading, the design load shall not exceed 2/3 of the value shown in the applicable design table; and
b. For lateral loading, the design load shall not exceed 5/6 of the value shown in the applicable design table.

Toe nails are recommended to be driven at an approximate angle of 30 degrees with the piece and started approximately 1/3 of the length of the nail from the end or side of the piece.

Timber Connection Adjustment for Duration of Load:

Tabulated values for timber fasteners are for normal duration of load and may be increased for short duration loading, except for connections used in falsework and formwork for post tensioned structures and staged construction sequences. Duration of load adjustment for timber connections shall not be allowed for all post tensioned structures and for staged construction sequences where delayed and/or staged loading occurs for any type of concrete structure. The adjustment for duration of load as described in this section applies only to design values for timber connectors, such as nails, bolts, and lag screws. Allowable stresses for timber and structural steel components used in the connection, as described in Section 6-02.3(17)C, are maximums and thus shall not be increased.

Tabulated values for nails, bolts, and lag screws may be adjusted by the following duration-of-load factors:

(1) 1.25 for falsework design governed by the minimum design horizontal load or greater (three percent or greater of the dead load);
(2) 1.33 for falsework design governed by wind load; and
(3) 2.00 for falsework design governed by impact loading.

6-02.3(17)K FACE LUMBER, STUDS, WALES, AND METAL FORMS

Elements of this section shall be designed for the loads, allowable stresses, deflections, and conditions which pertain from other subsections of Section 6-02.3(17).

Forms battered or inclined over the concrete tend to uplift as concrete is placed and shall have positive anchorage or counterweights designed to resist uplift and shall be shown in the formwork Shop Drawing submittal. Where the concrete pouring sequence causes fresh concrete to be significantly higher along one side of tied forms than the opposite side, a positive form anchorage system shall be designed Capable of resisting the imbalance of horizontal thrust, and prevent the dislocation and sliding of the entire form unit.

Wooden forms shall be faced with smooth sanded, exterior plywood. This plywood shall meet the requirements of the National Bureau of Standards, U.S. Product Standard PS 1, and the Design Specification of the American Plywood Association (APA). Each full sheet shall bear the APA stamp. The Contractor shall list in the formwork Shop Drawing submittal the grade and class of plywood. The Contractor may use plywood that does not carry the APA stamp if the plywood manufacturer submits a Manufacturer's Certificate of Compliance stating the plywood meets or exceeds the requirements of these Specifications for plywood. Plywood panels stamped “shop” or “shop cutting” shall not be used.

Plyform is an APA plywood specifically designed and manufactured for concrete forming. Plyform differs from conventional exterior plywood grades in strength and the exterior face panels are sanded smooth and factory oiled. Likewise, there is a significant difference between grades designated Class 1, Class 2, and Structural I Plyform.

The grades of plywood for various form applications shall be as follows:

1. **Traffic and Pedestrian Barriers** (except those that receive an architectural surface treatment) - Plywood used for these surfaces shall be APA grade High Density Overlaid (HDO) Plyform Class I. But if the Contractor coats the form to prevent it from leaving joint and grain marks on the surface, plywood that meets or exceeds APA grades B-B Plyform Class I or B-C (Group I species) may be used. Under this option, the Contractor shall provide for the Engineer’s review a 4-foot square test panel of concrete formed with the same plywood and coating as proposed in the form Shop Drawings. This panel shall include one form joint

along its centerline. The Contractor shall apply coating material, according to the manufacturer's instructions, before applying chemical release agents;

2. **Other Exposed Surfaces** (all but those on traffic and pedestrian barriers) – Plywood used to form these surfaces shall meet or exceed the requirements of APA grades B-B Plyform Class I or B-C (Group I series). If one face is less than B quality, the B (or better) face shall contact the concrete; and
3. **Unexposed Surfaces** (such as the undersides of roadway slabs between girders, the interiors of box girders, etc., and traffic and pedestrian barriers where surfaces are to receive an architectural treatment) - Plywood used to form these surfaces may be APA grade CDX, provided the Contractor complies with stress and deflection requirements stated elsewhere in these Specifications.

Form joints on an exposed surface shall be in a horizontal or vertical plane. But in wingwalls and box girders, side form joints shall be placed at right angles and parallel to the roadway grade. Joints parallel to studs or joists shall be backed by a stud or joist. Joints at right angles to studs and joists shall be backed by a stud or other equal performance backing. Perpendicular backing is not required if studs or joists are spaced:

a. Nine inches or less on center and covered with 1/2-inch plywood; or
b. Twelve inches or less on center and covered with 3/4-inch plywood.

The face grain of plywood shall run perpendicular to studs or joists unless shown otherwise on the reviewed Contractor's formwork Shop Drawings. Proposals to deviate from the perpendicular orientation shall be accompanied by supporting calculations of the stresses and deflections.

Forming for all exposed curved surfaces shall follow the shape of the curve shown on the Drawings and shall not be chorded except as follows. On any retaining wall that follows a horizontal circular curve, the wall stems may be a series of short chords if:

1) The chords within the panel are the same length;
2) The chords do not vary from a true curve by more than 1/2 inch at any point; and
3) All panel points are on the true curve.

Where architectural treatment is required, the angle point for chords in wall stems shall fall at vertical rustication joints.

For exposed surfaces of abutments, wingwalls, piers, retaining walls, and columns, the Contractor shall build forms of plywood at least 3/4-inch thick with studs no more than 12 inches on center. Deflection of the plywood, studs, or wales shall never exceed 1/500 of the span (or 1/360 of the span for unexposed surfaces, including the bottom of the deck slab between girders).

All form plywood shall be at least 1/2-inch thick except on sharply curved surfaces. There, the Contractor may use 1/4-inch plywood if it is backed firmly with heavier material.

Round columns or rounded pier shafts shall be formed with a self-supporting metal shell form or form tube that leaves a smooth, non-spiraling surface. Wood forms are not permitted.

Metal forms shall not be used elsewhere unless an acceptable surface can be demonstrated to the Engineer. Failure to provide and acceptable surface at any time will result in the Engineer requiring the Contractor to not use metal forms. If permitted to use a combination of wood and metal in forms, the Contractor shall coat the forms so that the texture produced by the wood matches that of the metal. Aluminum shall not be used for metal forms.

For design purposes, the Contractor shall assume that on vertical surfaces concrete exerts 150 pounds of pressure per square foot per foot of depth. However, when the depth is reached where the rate of placement controls the pressure, the following table applies:

Rate of Placing Feet per Hour	**Pressure, Pounds per Square Foot for Temperature of Concrete as Shown**	
	60 °F	**70 °F and above**
2	470	375
3	640	565
4	725	625
5	815	690
6	900	750
7	990	815
8	1,075	875
9	1,165	935
10	1,250	1,000
15	1,670	1,300

The pressures in the above table have been increased to provide an allowance for the vibration and impact.

Horizontal surfaces shall support a pressure of 160 pounds per square foot for each foot of concrete height.

All exposed corners shall be beveled 3/4-inch. However, traffic barriers, footings, footing pedestals and seals need not be beveled unless the Contract requires it.

All forms shall be as mortartight as possible with no water standing in them as the concrete is placed.

The Contractor shall apply a parting compound on forms for exposed concrete surfaces. This compound shall be a chemical release agent that permits the forms to separate deanly from the concrete. The compound shall not penetrate or stain the surface and shall not attract dirt or other foreign matter. After the forms are removed, the concrete surface shall be dust-free and have a uniform appearance. The Contractor shall apply the compound at the manufacturer's recommended rate to produce a surface free of dusting action and yet provide easy removal of the forms.

If an exposed concrete surface is to be sealed, the release agent shall not contain silicone resin. Before applying the agent, the Contractor shall submit to the Engineer a Manufacturer's Certificate of Compliance stating whether the resin in the base material is silicone or non-silicone.

The Contractor shall submit to the Engineer a sample and catalog cut of the parting compound at least 10 Working Days before its use. Approval or nonapproval shall be based on laboratory tests results.

The Engineer may reject any forms that are not able to produce an acceptable surface.

6-02.3(17)L FORMS ON STEEL SPANS

Forms for concrete placement on all steel structures shall be removable and shall not remain in place. Where needed, the forms shall have openings for truss or girder members. Each opening shall be large enough to leave at least 1-1/2 inches between the concrete and steel on all sides of the steel member after the forms have been removed.

Any form support for a roadway slab that rests on a plate girder flange shall apply the load within 6 inches of the girder web centerline. The Contractor shall not weld any part of the form to any steel member.

If the Engineer permits bolt holes in the web to support form brackets, the holes shall be shop-drilled. The Contractor shall fill the holes with fully torqued AASHTO M 164 bolts per Section 6-03.3(33). Each bolt head shall be placed on the exterior side of the web. There shall be no holes made in the flanges.

6-02.3(17)M FINISHING MACHINE SUPPORT SYSTEM

Before using any finishing machine, the Contractor shall submit to the Engineer for review, detailed Shop Drawings that show the system proposed to support it. The Contractor shall not attach this (or any other) equipment support system to the sides or suspend it from any girder. The Engineer will not permit such a method if it unduly alters stress patterns or creates too much stress in the girder.

6-02.3(17)N RESTRICTED OVERHEAD CLEARANCE SIGN

The Contractor shall notify the Engineer not less than 15 Working Days before the anticipated start of each falsework and girder erection operation whenever such falsework or girders reduce clearances available to the public traffic. Falsework openings shall not be more restrictive to traffic than shown on the Drawings.

Where the height of vehicular openings through falsework is less than 15 feet 0 inches, a W 12-2 "Low Clearance Symbol Sign" shall be erected on the shoulder in advance of the falsework, and two or more W 12-301 and/or W 12-302 signs shall be attached to the falsework to provide accurate usable clearance information over the entire falsework opening. The posted low clearance shall include an allowance for anticipated falsework girder deflection (rounded-up to the next whole inch) due to design dead load, including all successive concrete pours. W 12-302 signs shall be used to designate prominent clearance restrictions and limits of usable clearance. In addition, where the clearance is less than the legal height limit (14 feet 0 inches), a W 12-2 sign shall be erected in advance of the nearest intersecting road or wide point in the road at which a vehicle can detour or turn around. A W 13-501 sign indicating the distance to the low clearance shall be installed below the advance sign. The Engineer will furnish the above noted signs and the Contractor shall erect and maintain them, all in accordance with Sections 1-07.23 and 1-10, and the Contract.

When erecting falsework that restricts overhead clearance above a railroad track, the Contractor shall place restricted overhead clearance signs as soon as the restriction occurs. Sign details are shown in WSDOT Standard Plan no.G-1.

6-02.3(17)O REMOVAL OF FALSEWORK AND FORMS

The Contractor shall obtain the Engineer's written approval for the removal of forms or falsework. The Engineer will determine, on the basis of post-placement curing conditions, the exact number of curing days that shall elapse before form removal. The Contractor may request the removal of forms (from the time of the last pour the forms support) as indicated in the table that follows. Both compressive strength and curing days criteria shall be met if both are listed:

Concrete Placed In	% of Specified Minimum Compressive Strength	Number of Curing Days
Columns, wall faces, mass piers and abutments (except pier caps), traffic and pedestrian barriers, and any other side form not supporting the concrete weight.[1]	---	3
Pier caps continuously supported.[2]	60	3
Sidewalks not supported on bridge roadway slabs.[2]	70	---
Crossbeams, caps, pier caps not continuously supported, struts and top slabs on concrete box culverts, inclined columns and inclined walls .[2,3]	80	5
Roadway slabs supported on wood or steel stringers or on steel or prestressed concrete girders.[2]	80	10
Box girders, T-beam girders, and flat-slab s uperstructure.[2,3]	80	14
Arches.[2,3]	---	21

NOTES [1]Where forms do not support the load of concrete.

[2]Where forms support the load of concrete.

[3]Where continuous spans are involved, the time for all spans will be determined by the last concrete placed affecting any span.

Before releasing supports from beneath beams and girders, the Contractor shall remove forms from columns to enable the Engineer to inspect the column concrete.

The Contractor may remove the side forms of footings 24 hours after concrete placement if a curing compound is applied immediately. But this compound shall not be applied to the area of the construction joint between the footing and the column or wall.

The Contractor may remove side forms, traffic barrier forms, and pedestrian barrier forms after 24 hours if these forms are made of steel or dense plywood, an approved water reducing admixture is used, and the concrete reaches a compressive strength of 1,400 psi before form removal. This strength shall be proved by test cylinders made from the last concrete placed into the form. The cylinders shall be cured according to Field Operating Procedure for AASHTO T 23, Method 2.

Wet curing shall comply with the requirements of Section 6-02.3(11). The concrete surface shall not become dry during form removal or during the entire curing period.

Before placing forms for traffic and pedestrian barriers, the Contractor shall completely release all falsework under spans.

Before releasing forms under concrete cured at temperatures colder than 50°F, the Contractor shall first prove that the concrete meets desired strength - regardless of the time that has elapsed.

The Engineer may approve leaving in place forms for footings in cofferdams or cribs. This decision will be based on whether removing them would harm the cofferdam or crib and whether the forms are indicated as showing in the finished Structure.

All cells of a box girder structure having permanent access shall have all forms completely removed, including the roadway deck forms. All debris and all projections into the cells shall be removed. Unless otherwise indicated in the Contract, the roadway slab interior forms in all other cells where no permanent access is available, may be left in place.

Falsework and forms supporting sloping exterior webs shall not be released until the roadway deck and deck overhang concrete has obtained its removal strength and time of cure. Stern reshoring shall not be used.

Open joints shown on the Drawings shall have all forms completely removed, including styrofoam products and form anchors, allowing the completed structure to move freely.

If the Contractor intends to support or suspend falsework and formwork from the bridge Structure while the falsework and formwork is being removed, the Contractor shall submit a falsework and formwork removal plan and calculations in accordance with Section 1-05.3(12) for review. The falsework and formwork removal plan shall include the following:

1. The location and size of any cast-in-place falsework lowering holes and how the holes are to be filled;
2. The location, capacity, and size of any attachments, beams, cables, and other hardware used to attach to the structure or support the falsework and formwork;
3. The type, capacity and factor of safety, weight, and spacing of points of reaction of lowering equipment; and
4. The weight at each support point of the falsework and formwork being lowered.

All other forms shall be removed, whether they are above or below the level of the ground or water. Sections 6-02.3(6) and 6-02.3(7) govern form removal for concrete exposed to sea water or to alkaline water or soil. The forms inside of hollow piers, girders, abutments, etc. shall be removed through openings provided for that purpose as indicated on the Drawings.

6-02.3(17)P EARLY CONCRETE TEST CYLINDER BREAKS

The fabrication, curing and testing of the early cylinders shall be the responsibility of the Contractor. Early cylinders are defined as all cylinders tested in advance of the design age of 28 days whose purpose is to determine the in-place strength of concrete in a structure prior to applying loads or stresses. The Contractor shall retain an accredited independent testing laboratory, to be approved by the Engineer, to perform this work. The Contractor shall submit the independent testing laboratory's credentials and experience for doing testing as indicated in this Section to the Engineer at least 5 Working in advance of performing any testing.

The concrete cylinders shall be molded in accordance with Field Operating Procedure for AASHTO T 23 from concrete last placed in the forms and representative of the quality of concrete placed in that pour.

The cylinders shall be cured in accordance with Field Operating Procedure for AASHTO T 23, Method 2. The Engineer may approve the use of cure boxes meeting the requirements of this test method. Special cure boxes to enhance cylinder strength will not be allowed.

The concrete cylinders shall be tested for compressive strength in accordance with AASHTO T 22. The number of early cylinder breaks shall be in accordance with the Contractor's need and as approved by the Engineer.

The Contractor shall furnish the Engineer with all test results. The test results will be reviewed and approved before any forms are removed. The Contractor shall not remove forms without the approval of the Engineer.

Test laboratories used for this work shall be ASTM or AASHTO accredited, and shall be approved by the Engineer.

6-02.3(18) PLACING ANCHOR BOLTS

The Contractor shall comply with the following requirements in setting anchor bolts in piers, abutments, or pedestals:

1) If set in the wet concrete, the bolts shall be accurately placed before the concrete is placed;
2) If the bolts are set in drilled holes, hole diameter shall exceed bolt diameter by at least 1 inch. Grouting shall comply with Section 6-02.3(20);
3) If the bolts are set in pipe, grouting shall comply with the requirements for grouting shoes in Section 6-02.3(20); and
4) If freezing weather occurs before bolts can be grouted into sleeves or holes, they shall be filled with an approved antifreeze solution (non-evaporating).

6-02.3(19) BRIDGE BEARINGS

6-02.3(19)A ELASTOMERIC BEARING PADS

The Contractor shall use rubber cement to bond the lower contact surface of elastomeric bearing pads to the structure.

6-02.3(19)B BRIDGE BEARING ASSEMBLIES

For all fixed, sliding, or rolling bearings, the Contractor shall:

(1) Machine all sliding and rolling surfaces true, smooth, and parallel to the movement of the bearing;
(2) Polish all sliding surfaces;
(3) Anchor expansion bearings securely, setting them true to line and grade;
(4) Coat all sliding surfaces thoroughly with oil and graphite just before placing them into position; and
(5) Avoid placing concrete in such a way that it might interfere with the free action of any sliding or rolling surface.

Grout placement under steel bearings shall comply with Section 6-02.3(20).

6-02.3(20) GROUT FOR ANCHOR BOLTS AND BRIDGE BEARINGS

Grout shall be a prepackaged grout, mixed, placed, and cured as recommended by the manufacturer, or the grout shall be produced using Type I or Type II Portland cement, fine aggregate Class 1 (see Section 9-03.1(2)C), and water, in accordance with these Specifications.

Grout shall meet the following requirements:

Requirement	Compressive Strength
Test Method	AASHTO T 106
Values	4,000 psi @ 7 days

Grout shall be a workable mix with flowability suitable for the intended application.

If the Contractor elects to use a prepackaged grout, a material sample and laboratory test data from an independent testing laboratory shall be submitted to the Engineer for approval with the request for approval of Material sources (see Section 1-06.1).

If the Contractor elects to use a grout consisting of Type II Portland cement, fine aggregate Class 1, admixture, and water, the mix proportions and laboratory test data from an independent ASTM accredited test laboratory shall be submitted to the Engineer for approval with the request for approval of Material sources.

The Contractor shall first obtain approval of the grout from the Engineer before using the grout.

Field grout cubes shall be made in accordance with WSDOT Test Method 813 for either prepackaged grout or a Contractor provided mix when requested by the Engineer, but not less than per bridge pier or one per day.

The concrete receiving the grout shall first be thoroughly cleaned, roughened, and wetted with water to ensure proper bonding. The grout pad shall be cured as recommended by the manufacturer or kept continuously wet with water for three days.

Before placing grout into anchor bolt sleeves or holes, the cavity shall be thoroughly cleaned and wetted to ensure proper bonding.

To grout bridge bearing plates, the Contractor shall:

1. Build a form approximately 4 inches high, with sides 4 inches outside the base of each steel bearing plate;
2. Fill each form with grout to the depth indicated on the Drawings;
3. Work grout under all parts of each bearing plate;
4. Remove each form after the grout has hardened;
5. Remove the grout outside each bearing plate to the base of the bearing plate;
6. Bevel off the grout neatly to the top of the masonry; and
7. Place no additional load on the bearing plate until the grout has set at least 72 hours.

After all grout under the bearing plate and in the anchor bolt cavities has attained a minimum strength of 4,000 psi, the anchor bolt nuts shall be tightened to snug-tight. "Snug-tight" means either the tightness reached by (1) a few blows from an impact wrench, or (2) the full effort of a man using a spud wrench. Once the nut is snug-tight the anchor bolt threads shall be burred just enough to prevent loosening of the nut.

6-02.3(21) DRAINAGE OF BOX GIRDER CELLS

To drain box girder cells, the Contractor shall provide and install, according to details on the Drawings, short lengths of nonmetallic pipe in the bottom slab at the low point of each cell. The pipe shall have a minimum inside diameter of 4 inches. If the difference in plan elevation is 2 inches or less, the Contractor shall install pipe in each end of the box girder cell.

6-02.3(22) DRAINAGE OF SUBSTRUCTURE

The Contractor shall use weep holes and gravel backfill that complies with Section 9-03.12(2) to drain fill material behind retaining walls, abutments, tunnels, and wingwalls. To maintain thorough drainage, weep holes shall be placed as low as possible. Gravel backfill shall be placed and compacted as required in Section 2-09.3(1)E. Tiling, French or rock drains, or other drainage devices shall also be installed if indicated on the Drawings.

If underdrains are not installed behind the wall or abutment, all backfill within 18 inches of weep holes shall comply with Section 9-03.12(4). Unless the Contract requires otherwise, all other backfill behind the wall or abutment shall be gravel backfill for walls.

6-02.3(23) OPENING TO TRAFFIC

Bridges with a roadway slab made of Portland cement concrete shall remain closed to all traffic, including construction equipment, until the concrete has reached the 28-day specified compressive strength. This strength shall be determined by testing cylinders made of the same concrete as the roadway and cured under the same conditions. A concrete deck bridge shall never be opened to traffic earlier than 10 days after the deck concrete was placed and never without written approval of the Engineer.

See Section 6-01.6 for load restrictions on bridges under construction.

6-02.3(24) REINFORCEMENT

6-02.3(24)A GENERAL

The Contractor shall submit Shop Drawings showing the rebar list and bending diagram to the Engineer for review prior to fabrication in accordance with Section 1-05.3. The submittal shall include information on welding as specified in Section 6-02.3(24)F.

Various steel reinforcing bars, including those in crossbeams, may be shown as straight in the bar list. The Contractor shall bend these bars as required to conform to the configuration of the structure and as detailed on the Drawings.

6-02.3(24)B FIELD BENDING

If the Drawings call for field bending of steel reinforcing bars, the Contractor shall bend them in keeping with the structural configuration indicated in, and in accordance with, the Contract.

Bending steel reinforcing bars partly embedded in concrete shall be done as follows:

Field bending shall not be done:

1. On bars size No. 14 or No. 18;
2. When air temperature is lower than 45°F;
3. By means of hammer blows or pipe sleeves; or
4. While the bar temperature is in the range of 400°F to 700°F.

In field-bending steel reinforcing bars, the Contractor shall:

1) Make the bend gradually;
2) Apply heat as described in Tables 2 and 3 for bending bar sizes No. 6 through No. 11 and for bending bar sizes No. 5 and smaller when the bars have been previously bent. Previously unbent bars of sizes No. 5 and smaller may be bent without heating;
3) Use a bending tool equipped with a bending diameter as listed in Table 1;

4) Limit any bend to these maximums -- 135 degrees for bars smaller than size No. 9, and 90 degrees for bars size No. 9 through 11; and
5) Straighten by moving a hickey bar (if used) progressively around the bend.

In applying heat for field-bending steel reinforcing bars, the Contractor shall:

(1) Use methods that avoid damage to the concrete;
(2) Insulate any concrete within 6 inches of the heated bar area;
(3) Ensure, by using temperature-indicating crayons or other suitable means, that steel temperature never exceeds the maximum temperatures shown in the following Table 2;
(4) Maintain the steel temperature within the required range shown in the following Table 2 during the entire bending process;
(5) Apply two heat tips simultaneously at opposite sides of bars larger than Size No. 6 to assure a uniform temperature throughout the thickness of the bar. For Size No. 6 and smaller bars, apply two heat tips, if necessary;
(6) Apply the heat for a long enough time that within the bend area the entire thickness of the bar-- including its center-- reaches the required temperature;
(7) Bend immediately after the required temperature has been reached;
(8) Heat at least as much of the bar as the following Table 3 requires;
(9) Locate the heated section of the bar to include the entire bending length; and
(10) Never cool bars artificially with water, forced air, or other means.

TABLE 1

Bending Diameters for Field-Bending Reinforcing Bars

Bar Size	**Bend Diameter/Bar Diameter Ratio**	
	Heat Not Applied	**Heat Applied**
No. 4, No. 5	8	8
No. 6 through No. 9	Not Permitted	8
No. 10, No. 11	Not Permitted	10

The minimum bending diameters for stirrups and ties for No. 4 and No. 5 bars when heat is not applied shall be specified in Section 9-07.

TABLE 2

Preheating Temperatures for Field-Bending Reinforcing Bars

Bar Size	**Temperature (°F)**	
	Minimum	**Maximum**
No. 4	1,200	1,250
No. 5, No. 6	1,350	1,400
No. 7 through No. 9	1,400	1,450
No. 10, No. 11	1,450	1,500

TABLE 3

Minimum Bar Length to be Heated
(d = nominal diameter of bar)

Bar Size	**Bend Angle**		
	45°	**90°**	**135°**
No. 4 through No. 8	8d	12d	15d
No. 9	8d	12d	Not Permitted
No. 10, No. 11	9d	14d	Not permitted

6-02.3(24)C PROTECTION OF MATERIALS

The Contractor shall protect reinforcing steel from all damage. When placed into the structure, the steel shall be free from dirt, loose rust or mill scale, paint, oil, and other foreign matter.

When transporting, storing, or constructing in close proximity to bodies of salt water, plain and epoxy-coated steel reinforcing bar shall be kept in enclosures that provide protection from the elements.

If plain or epoxy-coated steel reinforcing bar is exposed to mist, spray, or fog that may contain salt, it shall be flushed with fresh water prior to concrete placement.

When the Engineer requires protection for reinforcing steel that is to remain exposed for a length of time, the Contractor shall protect the reinforcing steel:

1. By cleaning and applying a coat of paint Formula No. A-9-73 over all exposed surfaces of steel; or
2. By cleaning and painting paint Formula No. A-9-73 on the first 6 inches of the steel bars protruding from the concrete and covering the bars with polyethylene sleeves.

The paint shall have a minimum dry film thickness of 1 mil.

6-02.3(24)D PLACING AND FASTENING

The Contractor shall position reinforcing steel as the Drawings require and shall ensure that the steel is not displaced as the concrete is placed.

When spacing between bars is 1 foot or more, they shall be tied at all intersections. When spacing is less than 1 foot, every other intersection shall be tied. Bundled bars shall be tied together with wires at least every 6 feet. Wire ties used for tying epoxy-coated reinforcing steel shall be plastic coated. Tack welding is not permitted on reinforcing steel.

Abrupt bends in the steel are permitted only when one steel member bends around another. Vertical stirrups shall pass around main reinforcement or be firmly attached to it.

For slip-formed concrete, the reinforcing steel bars shall be tied at all intersections and crossbraced to keep the cage from moving during concrete placement. Crossbracing shall consist of additional reinforcing steel placed both longitudinally and transversely.

For slip-formed concrete barriers, the vertical dowels protruding from the supporting concrete structure shall be diagonally braced against bending induced by the advancing slip-form. The bracing bars shall be no smaller than No. 5 and shall be extended diagonally from the top of one expansion joint to the bottom of the next expansion joint and shall be securely tied to all intervening dowels. A horizontal top bar shall also be tied to all the dowels.

After reinforcing steel bars are placed in a traffic or pedestrian barrier and prior to slip-form concrete placement, the Contractor shall check clearances and reinforcing steel bar placement. This check shall be accomplished by using a template or by operating the slip-form machine over the entire length of the traffic or pedestrian barrier. All clearance and reinforcing steel bar placement deficiencies shall be corrected by the Contractor before slip-form concrete placement.

Mortar blocks (or other approved devices) shall be used to maintain the concrete coverage required by the Drawings. The mortar blocks shall:

1. Have a bearing surface measuring not greater than 2 inches in either dimension; and
2. Have a compressive strength equal to that of the concrete in which they are embedded.

In slabs, each mortar cube shall have either: (1) a grooved top that holds it in place, or (2) an embedded wire that protrudes and is tied to the reinforcing steel. Plastic coated ties shall be used around epoxy-coated bars.

Acceptance of mortar blocks shall be based on testing a set of two specimens. Each pair of specimens shall represent 2,500 or fewer mortar blocks and shall be made of the same mortar as the blocks and cured under the same conditions. The Contractor may either:

1) Submit the blocks to the Engineer for pre-use testing, or
2) Submit Manufacturer's Certificate of Compliance as specified in Section 1-06.3.

In lieu of mortar blocks, the Contractor may use metal or plastic chair supports to hold uncoated bars. Any surface of a metal chair support that is not to be covered by at least 1/2-inch of concrete shall be either:

(1) Hot-dip galvanized after fabrication in keeping with AASHTO M 232, Class D;
(2) Coated with plastic firmly bonded to the metal. This plastic shall be at least 3/32 inch thick where it touches the form and shall not react chemically with the concrete when tested in the SPU Materials Laboratory. The plastic shall not shatter or crack at or above – 5°F and shall not deform enough to expose the metal at or below 200°F; or
(3) Stainless steel that meet the requirements of ASTM A 493, Type 302. Stainless steel chair supports are not required to be galvanized or plastic coated.

In lieu of mortar blocks, epoxy-coated reinforcing bars may be supported by either:

A. Metal chair supports coated entirely with a dielectric material such as epoxy or plastic;
B. Other epoxy-coated reinforcing bars; or
C. Plastic chair supports.

Plastic chair supports shall be lightweight, non-porous, and chemically inert in concrete. Plastic chair supports shall have rounded seatings, shall not deform under load at normal temperatures, and shall not shatter or crack under impact loading in cold weather. Plastic chair supports shall be placed at spacings greater than 1 foot along the bar and shall have at least 25% of their gross place area perforated to compensate for the difference in coefficient of thermal expansion between plastic and concrete. The shape and configuration of plastic supports shall permit complete concrete consolidation in and around the support.

In roadway and sidewalk slabs, the Contractor shall place reinforcing steel mats carefully to provide the required concrete cover. A "mat" is 2 layers of steel. Top and bottom mats shall be supported enough to hold both in their proper positions. If No. 4 bars make up the lower layer of steel in a mat, it shall be blocked at not more than 3-foot intervals (or 4-foot intervals for bars No. 5 and larger). Wire ties to girder stirrups shall not be considered as blocking. The Contractor shall add other supports and tie wires to the top mat as needed to provide a rigid mat.

If a bar is indicated as interfering with a bridge drain, it shall be bent in the field to bypass the drain.

Clearances shall be at least:

A) **4 inches between:** Main bars and the top of any concrete masonry exposed to the action of salt or alkaline water.

B) **2-1/2 inches between:** Adjacent bars in a layer. Slab bars and the top of the roadway slab. Main bars and the surface of concrete deposited against earth (without intervening forms).

C) **2 inches between:** Adjacent layers. Main bars and the surface of concrete (except in walls and slabs). Reinforcing bars and the faces of forms for exposed aggregate finish.

D) **1-1/2 inches between:** Main bars and the surface of concrete in retaining walls. Slab bars and the top of the slab (except roadway slabs). Stirrups and ties and the surface of the concrete.

E) **1 inch between:** Slab bars and the bottom of the slab. Curb or sidewalk bars and the surface of the concrete.

Reinforcing steel bars shall not vary more than the following tolerances from their position shown on the Drawings:

Members 10 inches or less in thickness	±1/4 in.
Members more than 10 inches in thickness	±3/8 in.
Except:	
The distance between the nearest reinforcing steel bar surface and the top surface of the roadway deck slab	+1/4 in.
Longitudinal spacing of bends and ends of bars	±1 in.
Length of bar laps	-1-1/2 in.
Embedded length	
No. 3 through No. 11	-1 in.
No. 14 through No. 18	-2 in.
When reinforcing steel bars are to be placed at equal spacing within a plane:	
Stirrups and ties	±1 in.
All other reinforcement	±1 bar dia.

Before placing any concrete, the Contractor shall:

(A) Clean all mortar from reinforcement; and

(B) Obtain the Engineer's permission to place concrete after the Engineer has inspected the placement of the reinforcing steel. (Any concrete placed without the Engineer's permission will be rejected and shall be removed.)

6-02.3(24)E SPLICING

The Contractor shall supply steel reinforcing bars in the full lengths the Drawings require. Unless the Engineer approves otherwise in writing, the Contractor shall not change the number, type, or location of splices.

The Engineer may permit the Contractor to use thermal or mechanical splices in place of the method shown on the Drawings if they are of a Contractor submitted and Engineer reviewed design. Use of a new design may be granted by the Engineer if:

1. The Contractor provides technical data and proof from the manufacturer that the design shall perform as well as or better than the method shown on the Drawings, and
2. Sample splices and materials from the manufacturer pass the Engineer's tests.

After a new design has been reviewed, any further changes in detail or material shall require a new submittal for review.

The Contractor shall:

1) Not lap-splice reinforcing bars Nos. 14 or 18,
2) Not permit any welded or mechanical splice to deviate in alignment more than 1/4 inch per 3-1/2 feet of bar,
3) Distribute splices evenly, grouping them together only at points of low tensile stress,
4) Ensure at least 2 inches clearance between any splice and the nearest bar or the surface of the concrete (or 1-1/2 inches for the length of the sleeve on mechanical splices),
5) Rigidly clamp or wire all splices in a manner acceptable to the Engineer,
6) Place lap-spliced bars in contact for the length of the splice and tie them together near each end, and
7) Securely fasten the ends and edges of welded-wire-fabric reinforcement, overlapping them enough to maintain even strength.

6-02.3(24)F WELDING REINFORCING STEEL

Welding of steel reinforcing bars shall conform to the requirements of the Contract.

When welding is required, steel reinforcing bars shall be supplied that are suitable for welding. Steel which is to be welded shall have a maximum carbon equivalent of 0.65 percent. The carbon equivalent shall be determined by the following formula:

$$CE = \frac{\%\ C}{1} + \frac{\%\ Mn}{6} + \frac{\%\ Cu}{10} + \frac{\%\ Ni}{20} + \frac{\%\ Cr}{10} - \frac{\%\ Mo}{50} - \frac{\%\ V}{10}$$

In addition, carbon shall not exceed 0.45 % and manganese shall not exceed 1.30 %.

Before any welding begins, the Contractor shall submit to the Engineer's for review, a written welding procedure for each type of welded splice to be used, including the procedure specifications and joint details. The procedure specifications shall specify:

1. material specification;
2. manual or machine;
3. position of weld;
4. filler metal specification and classification;
5. shielding gas;
6. single or multiple pass;
7. single or multiple arc;
8. either shielded metal arc, flux cored arc, or gas metal arc welding process;
9. preheat and interpass temperature;
10. welding current;
11. polarity; and
12. root treatment.

The welding procedure shall specify:

1) welding sequence,
2) pass number,
3) electrode size,
4) welding current amperes, and
5) voltage for each joint detail.

All the aforementioned information shall be contained on a form that specifies the procedure number, revision number, and the Contractor. The form shall be signed and dated by the Contractor.

Electrodes for manual shielded metal arc welding (SMAW) of Grade 60 steel reinforcing bars shall conform to the requirements of AWS A5.5 of the low hydrogen E90 series.

Solid and composite electrodes for gas metal arc welding (GMAW) and flux-cored arc welding (FCAW) of Grade 60 steel reinforcing bar shall conform to the requirements of AWS A5.28, ER90S and AWS A5.29, E90T respectively. The Contractor shall demonstrate that each combination of electrode and shielding proposed for use produces the following mechanical properties:

FCAW Grade E90T	
Tensile Strength	90,000 psi
Yield Strength	78,000 psi
Elongation in 2 inches	17%

Compliance may be verified from manufacturer's certified test reports, or from actual testing of weld specimens.

All welding shall be protected from air currents, drafts, and precipitation to prevent loss of heat or loss of arc shielding. Short circuiting transfer with gas metal arc welding will not be allowed. Slugging of welds will not be allowed. No field welding of reinforcing bars will be permitted when the ambient temperature is below 32°F.

The minimum preheat and interpass temperature for welding Grade 60 reinforcing bars shall be 400°F. Preheating shall be applied to the reinforcing bars and other splice members within 6 inches of the weld, unless limited by the available lengths of the bars or splice member.

Generally, postheating of welded splices is only required for direct butt welded splices of Grade 60 bars size No. 9 or larger. Postheating shall be done immediately after welding before the splice has cooled to 700°F. Postheating shall not be less than 800°F nor more than 1,000°F and held at this temperature for not less than 10 minutes before allowing the splice to cool naturally to ambient temperature.

Weld joint and welder qualifications shall be made by the following procedures. The joint qualification and welder qualification shall be according to the following tests.

In the presence of the Engineer's Materials and Fabrication Inspector, the welder shall weld three test joints of the largest size reinforcing bar to be weld spliced. Two of the test welds shall be test loaded to no less than 125 percent of the minimum specified yield strength of the bar. The remaining test weld shall be mechanically cut perpendicular to the direction of welding and macroetched. Indirect butt splices shall be cut mechanically at two locations to provide a transverse cross section of each of the bars spliced in the test assembly. The sections shall show the full cross-section of the weldment, the root of the weld, and any reinforcement. The etched cross-section shall have complete penetration and complete fusion with the base metal and between successive passes in the weld. Groove welds of direct butt splices and flare-groove welds shall not have reinforcement exceeding 1/8-inch in height measured from the main body of the bar and shall have a gradual transition to the base metal surface. No cracks will be allowed in either the weld metal or heat-affected zone. All craters shall be filled to the full cross-section of the weld. Weld metal shall be free from overlap. Undercutting deeper than 1/32-inch will not be allowed except at points where welds intersect the raised pattern of deformations where undercutting less than 1/16-inch deep will be acceptable. The sum of diameters of piping porosity in groove welds shall not exceed 1/8-inch in any linear inch of weld or exceed 9/16 inch in any 6 inch length of weld. The Contractor shall first obtain approval of the Engineer for proposed corrections to welds with shielded metal arc, gas metal arc, or flux-cored arc welding processes.

A welder qualified in the vertical position shall then be qualified for the horizontal and flat positions. A welder qualified for the horizontal position shall then be qualified for the flat position but not the vertical position. A welder qualified in the flat position shall be qualified for the flat position only.

Welders qualified for direct butt splice groove welds are qualified for indirect butt splice groove welds and fillet welds. A welder qualified for indirect butt splice grooved welds is not qualified for direct butt splice welds. The welder qualifications shall remain in effect indefinitely unless:

1 the welder is not engaged in a given process of welding for which he/she is qualified for a period exceeding six months, or
2 there is some specific reason to question a welder's ability.

Weld joint geometry shall be as shown on the Drawings and in compliance with the Specifications. Welding machines shall be DC current, be reverse polarity, and be Capable of placing welds as specified.

The Contractor is responsible for using a welding sequence that limits the alignment distortion of the bars due to the effects of welding. The maximum out-of-line permitted will be 1/4-inch from a 3.5-foot straight edge centered on the weld and in line with the bar.

The following procedure for welding steel reinforcing bars is recommended:

> Sheared bar ends shall be burned or sawed off a minimum of 1/2-inch to completely remove the ruptured portion of the steel shear area prior to welding butt splices. Surfaces to be welded shall be smooth, uniform, and free from fins, tears, cracks, and other defects. Surfaces to be welded and surfaces adjacent to a weld shall also be free from loose or thick scale, slag, rust, moisture, grease, paint, epoxy covering, or other foreign materials. All tack welds shall be within the area of the final weld. No other tack weld will be permitted. Double bevel groove welds require chipping, grinding, or gouging to sound metal at the root of the weld before welding the other side. Progression of vertical welding shall be upward. The ground wire from the welding machine shall be clamped to the bar being welded.

Should the Contractor elect to use a procedure which differs in any way from the procedure recommended above, the Contractor shall submit the differing procedure with reasons for the changes to the Engineer for review. Engineer reviewed weld procedures shall be strictly followed.

6-02.3(24)G MECHANICAL SPLICES

The Contractor shall form mechanical splices with an Engineer-reviewed system using sleeve filler metal, threaded coupling, or another method that complies with this Section.

The Contractor shall adjust, relocate, or add stirrups, ties, and bars as needed to maintain required clearances after the splices are in place.

The Contractor shall provide the Engineer with the following information for each shipment of splice material before performing splicing:

1. The type or series identification (and heat treatment lot number for threaded-sleeve splices);
2. The grade and size of bars to be spliced;
3. A manufacturer's catalog with complete data on material and procedures;
4. A written statement from the manufacturer that the material is identical to that used earlier by the Engineer in testing and reviewing the system design; and
5. A written statement from the Contractor that the system and materials shall be used according to the manufacturer's instructions and all requirements of this Section.

All splices shall meet these criteria:

1) Tension splices shall develop at least 130 percent of the yield tensile strength specified for the unspliced bar. The ultimate tensile strength of the sleeve shall exceed that of the other parts of the completed splice;
2) AASHTO M 31 bars within a splice sleeve shall not slip more than 0.03 inch for Grade 40 bars, nor more than 0.045 inch for Grade 60 bars. This slippage shall be measured between gage points clear of the splice sleeve. Measurements shall be taken at an initial load of 3,000 psi and again after loading to 90 percent of the minimum specified yield strength for the unspliced bar and then relaxed to 3,000 psi; and
3) Maximum allowable bar size:
   a. Mechanical butt splice — No. 14 bar
   b. Mechanical lap splice — No. 6 bar

The Engineer will visually inspect the splices and accept all that appear to conform with the test samples. For sleeve-filler splices, the Engineer will allow voids within the limits on file in the design review. If the Engineer considers any splice defective, it shall be removed and replaced at the Contractor's sole expense.

In preparing sleeve-filler metal splices, the Contractor shall:

(1) Clean the bar surfaces by:
   (a) oxyacetylene torch followed by power wire brushing, or
   (b) abrasive blasting;
(2) Remove all slag, mill scale, rust, and other foreign matter from all surfaces within and 2 inches beyond the sleeve;
(3) Grind down any projection on the bar that would prevent placing the sleeve;
(4) Prepare the ends of the bars as the splice manufacturer recommends and as the Engineer reviewed procedure requires; and
(5) Preheat, just before adding the filler, the entire sleeve and bar ends to 300°F, ±50F°. (If a gas torch is used, the flame shall not be directed into the sleeve.)

When a metallic, sleeve-filler splice is used (or any other system requiring special equipment), both the system and the operator shall qualify in the following way under the supervision of the Engineer. The operator shall prepare 6 test splices (3 vertical, 3 horizontal) using bars having the same AASHTO Designation and size (maximum) as those to be used in the work. Each test sample shall be 42 inches long and shall consist of two 21-inch bars joined end-to-end by the splice. The bar alignment shall not deviate more than 1/8 inch from a straight line over the whole length of the sample. All 6 samples must meet both the tensile strength and the slip criteria specified in this Section.

The Contractor shall provide labor, materials, and equipment for making these test samples at no additional cost to the Owner. The Owner will test the samples at no cost to the Contractor.

6-02.3(24)H JOB CONTROL TESTS

As the work progresses, the Engineer may require the Contractor to provide a sample splice (thermal or mechanical *or both*) to be used in a job control test. The operator shall create this sample on the job site with the Engineer present using bars of the same size as those being spliced in the work. The sample shall comply with all requirements of these Specifications, and is in addition to all other sample splices required for qualification. The Engineer will require no more than two acceptable samples that conform to the specified splicing procedures on any project with fewer than 200 splices and no more than one acceptable sample per 100 splices on any project with more than 200 splices.

6-02.3(24)I EPOXY-COATED STEEL REINFORCING BAR

This work is furnishing, fabricating, coating, and placing epoxy-coated steel reinforcing bars as shown in the Contract. Coating material shall be applied electrostatically, by spraying, or by the fluidized-bed method.

All epoxy-coated bars shall comply with the requirements of Section 9-07. Fabrication may occur before or after coating.

The Contractor shall protect epoxy-coated bars from damage using padded or nonmetallic slings and straps free of dirt or grit. The Contractor shall lift bundled bars with a strong-back, multiple supports, or a platform bridge to prevent abrasion from bending or sagging. Bundled bars shall not be dropped or dragged. Bars shall rest on wooden or padded cribbing during shop or field storage. The Contractor may substitute other methods for protecting the bars if the Engineer approves. Coated bars that have significant damage (significant damage defined in this Specification Section) will be rejected.

Metal chairs and supports shall be coated with epoxy or other inert coating approved in writing by the Engineer. The Contractor may use other support devices with prior written approval of the Engineer. Plastic coated tie wires, approved in writing by the Engineer, shall be used to protect the coated bars from being damaged during placement.

The bars shall be placed as indicated on the Drawings. The bars shall be secured firmly in place during placing and setting of the concrete. All epoxy-coated bars in the top mat of the roadway slab, and epoxy-coated bars with spacing intervals of 1 foot or greater, shall be tied at all intersections. Epoxy-coated bars not in the top mat of the roadway slab, and with bar spacing intervals of less than 1 foot, shall be tied at alternate intersections.

The Contractor shall protect the epoxy-coating from damage that might result from other construction work in the interval between installing coated bars and concreting the deck.

The Engineer will inspect the coated bars after they are placed and again before the deck concrete is placed. The Contractor shall patch any areas that show significant damage defined as follows.

Significant damage means the Engineer has determined any opening in the coating that exposes the steel in an area that exceeds:

1. 0.05 square inch (approximately 1/4 inch square or 1/4 inch in diameter or the equivalent);
2. 0.012 square inch (approximately 1/8 inch square or 1/8 inch in diameter) when the opening is within 1/4 inch of another opening of equal or larger size;
3. 6 inches long, any width; or
4. 0.50 square inch aggregate area in any 1-foot length of bar.

The Contractor shall patch significantly damaged areas with a patching material obtained from the epoxy resin manufacturer which has been submitted to and reviewed by the Engineer. This patching material shall be compatible with the coating and inert in concrete. Areas to be patched shall be clean and free of surface contaminants. Patching shall be done before oxidation occurs and according to the resin manufacturer's instructions.

6-02.3(25) PRESTRESSED CONCRETE GIRDERS

6-02.3(25)A GENERAL

The manufacturing plant of prestressed concrete girders shall be certified by the Precast/Prestressed Concrete Institute's Plant Certification Program for the type of prestress member to be produced and shall be approved by WSDOT as a

Certified Prestress Concrete Fabricator prior to the start of production as part of WSDOT's annual plant review and approval process. Proof of plant certification by P/PCI and by WSDOT shall be submitted along with the Shop Drawings by the Contractor to the Engineer.

The Contractor shall provide the Engineer at least 3 Working Days advance notice of the girder production schedule. The Contractor shall give the Engineer safe and unencumbered access to the work. If non-Specification work or unacceptable quality control practices are observed, the Engineer will advise the plant manager with written notice. The proposed corrective action shall be acceptable to the Engineer. Failure to provide acceptable corrective action will be cause for rejection of the girder(s).

All reinforcement, from manufacture to encasement in concrete, used in girders shall be protected against contamination such as dirt, oil, grease, damage, rust, all corrosives, and any other material deleterious for its intended use. The proposed protection method requires the Engineer’s advance written approval. Reinforcement will be rejected if found contaminated.

The various types of girders are:

Prestressed Concrete Girder - Refers to prestressed concrete girders including Series W42G, W50G, W58G, and W74G girders, bulb tee girders, and deck bulb tee girders.
Bulb Tee Girder - Refers to a bulb tee girder or a deck bulb tee girder.
Deck Bulb Tee Girder - Refers to a bulb tee girder with a top flange designed to support traffic loads (i.e., without a cast-in-place deck). This type of bulb tee girder is mechanically connected to adjacent girders at the Project Site.

6-02.3(25)B SHOP DRAWINGS

The Drawings show design conditions and details for prestressed girders. Deviations will not be permitted, except as specifically allowed by these Specifications and by manufacturing processes approved by the annual plant approval process.

Shop Drawings shall show the size and location of all cast-in holes for installation of deck formwork hangers and/or temporary bracing. Holes for formwork hangers shall match Engineer reviewed deck formwork Shop Drawings designed in accordance with Section 6-02.3(16). There shall be no field-drilled holes in prestressed girders.

The Contractor shall have the option to furnish Series W74G prestressed concrete girders with minor dimensional differences from those shown on the Drawings. The 2-5/8-inch top flange taper may be reduced to 1-5/8-inch and the bottom flange width may be increased to 2-feet 2-inches. Other dimensions of the girder shall be adjusted as necessary to accommodate the above mentioned changes. Reinforcing steel shall be adjusted as necessary. The overall height and top flange width shall remain unchanged.

If the Contractor elects to provide a Series W74G girder with an increased web thickness, Shop Drawings along with supporting design calculations in accordance with Section 1-05.3(12) shall be submitted to the Engineer for review prior to girder fabrication. The girder shall be designed for at least the same load carrying capacity as the girder shown on the Drawings. The load carrying capacity of the mild steel reinforcement shall be the same as that shown on the Drawings.

The Contractor may alter bulb tee girder dimensions as indicated from that shown on the Drawings if:

1. The girder has the same or higher load carrying capacity (using current AASHTO Design Specification);
2. The Engineer reviews, before the girder is made, complete design calculations for the girder;
3. The Contractor adjusts substructures to yield the same top of roadway elevation shown on the Drawings;
4. The depth of the girder is not increased by more than 2 inches and is not decreased;
5. The web thickness is not increased by more than 1 inch and is not decreased;
6. The top flange minimum thickness of the girder is not increased by more than 2 inches, providing the top flange taper section is decreased a corresponding amount;
7. The top flange taper depth is not increased by more than 1 inch; and
8. The bottom flange width is not increased by more than 2 inches.

The Contractor shall provide four copies of the Shop Drawings to the Engineer. Only steel side forms are acceptable, except plywood forms are acceptable on the end bulkheads.

6-02.3(25)C CASTING

Before casting girders, the Contractor shall have possession of the Engineer reviewed set of Shop Drawings.

All concrete mixes to be used shall be submitted in accordance with the requirements of Section 9-19.1. The temperature of the concrete when placed shall be between 50°F and 90°F.

Slump shall not exceed 4 inches for normal concrete nor 7 inches with the use of a high range water reducing admixture. The high range water reducer shall meet the requirements of Section 9-23.6, 9-23.7, and 9-23.8. When the slump exceeds the maximum slump specified, the acceptability of the concrete shall be subject to the provisions of Section 6-02.3(4).

Air-entrainment is not required in the concrete placed into prestressed precast concrete girders unless otherwise specified in the Contract. The Contractor shall use air-entrained concrete in the entire roadway deck flange of deck bulb-tee girders. Maximum and minimum air content shall be as specified in Section 6-02.3(2)B.

No welds will be permitted on steel within prestressed girders. Once the prestressing steel has been installed, no welds or grounds for welders shall be made on the forms or the steel in the girder, except as specified.

The Contractor may form circular block-outs in the girder top flanges to receive falsework hanger rods. These block-outs shall:

1. Not exceed 1 inch in diameter;
2. Be spaced no more than 72 inches apart longitudinally on the girder;

3. Be located 3 inches or more from the outside edge of the top flange on Series W42G, W50G and W58G girders, and 6 inches or more for Series W74G girders; and
4. Be located within 15 inches of the web centerline for bulb tee girder.

The Contractor may form circular block-outs in the girder webs to support brackets for roadway slab falsework. These block-outs shall:

1) Not exceed 1 inch in diameter;
2) Be spaced no more than 72 inches apart longitudinally on the girder; and
3) Be positioned so as to clear the girder reinforcing and prestressing steel.

6-02.3(25)D PRESTRESSING

Each stressing system shall have a pressure gauge or load cell that measures jacking force. Any gauge shall display pressure accurately and readably with a dial at least 6 inches in diameter or with a digital display. Each jack and its gauge shall be calibrated as a unit and shall be accompanied by a certified calibration curve allowing tension stress to be determined. The calibration and certification shall be obtained from an AASHTO certified testing laboratory acceptable to the Engineer. The Contractor shall provide one copy of this certified calibration curve to the Engineer. The cylinder extension during calibration shall be in the approximate position it occupies at final jacking force.

Jacks and gauges shall be recalibrated and recertified:

1. Annually;
2. After any repair or adjustment; and
3. Anytime there are indications that the jack calibration is in error.

The Engineer may engage an independent testing laboratory to check jacks, gauges, and calibration charts before and during tensioning.

All load cells or pressure gauges shall be calibrated as specified above in this Section and shall have an indicator that shows prestressing force in the strand. The range of the load cell shall be broad enough that the lowest 10 percent of the manufacturer's rated capacity shall not be used to measure jacking force.

See Section 6-02.3(25)A for protection of reinforcement.

6-02.3(25)E CURING

During curing, the Contractor shall keep the girder in a saturated curing atmosphere until the girder concrete has reached the required release strength. The Contractor with advance notification to the Engineer for review, may shorten curing time by heating the outside of impervious forms. Heat may be radiant, convection, conducted steam, or hot air. With steam, the arrangement shall envelop the entire surface with saturated steam. The Engineer will not permit hot air curing until after reviewing the Contractor's proposed method to envelop and maintain the girder in a saturated atmosphere. Saturated atmosphere means a relative humidity of at least 90 percent. The Contractor shall never allow dry heat to touch the girder surface at any point.

Under heat curing methods, the Contractor shall:

1. Keep all unformed girder surfaces in a saturated atmosphere throughout the curing time;
2. Embed a thermocouple (linked with a thermometer accurate to ± 5F°) 6 to 8 inches from the top or bottom of the girder on its centerline and near its midpoint;
3. Monitor with a recording sensor (accurate to ± 5F°) arranged and calibrated to continuously record, date, and identify concrete temperature throughout the heating cycle;
4. Make this temperature record available *to* the Engineer;
5. Heat concrete to no more than 100°F during the first two hours after placing the concrete, and then increase no more than 25°F per hour to a maximum of 175°F;
6. Cool the concrete, after curing is complete, at a rate not to exceed 25°F per hour, to 100°F; and
7. Keep the temperature of the concrete above 60°F until the girder reaches release strength.

The Contractor may strip side forms once the concrete has reached a minimum compressive strength of 3,000 psi. All damage from stripping is the Contractor's responsibility and shall be repaired in a manner acceptable to the Engineer at no additional cost to the Owner.

6-02.3(25)F CONTRACTORS CONTROL STRENGTH

Concrete strength shall be measured using test cylinders cast from the same concrete as that in the girder. These cylinders shall be cured under time-temperature relationships and conditions that simulate those of the girder. If the forms are heated by steam or hot air, test cylinders shall remain in the coolest zone throughout curing. If forms are heated another way, the Contractor shall provide a record of the curing time-temperature relationship for the cylinders for each girder to the Engineer. When two or more girders are cast in a continuous line and in a continuous pour, a single set of test cylinders may represent all girders provided the Contractor demonstrates acceptable uniformity of casting and curing to the Engineer.

The Contractor shall mold, cure, and test enough of these cylinders to comply with specification requirements for measuring concrete strength. The Contractor may use 4 inch by 8 inch or 6 inch by 12 inch cylinders. If heat is used to shorten curing time, the Contractor shall let cylinders cool for at least 1/2 hour before testing.

Test cylinders may be cured in a moist room or water tank in accordance with AASHTO T 23 after the girder concrete has obtained the required release strength. If, however, the Contractor intends to ship the girder prior to the standard 28 day strength test, the design strength for shipping shall be determined from cylinders placed with the girder and cured under the same conditions as the girder. These cylinders may be placed in a noninsulated, moisture-proof envelope.

To measure concrete strength in the girder, the Contractor shall randomly select two test cylinders and average their compressive strengths. The compressive strength in either cylinder shall not fall more than 5 percent below the specified strength. If the first set of two cylinders do not pass the test, a second set of two other cylinders shall be selected and tested.

If too few cylinders were molded to carry out all required tests on the girder, the Contractor shall remove and test cores from the girder. The collection and testing of these girder test cores shall be performed in the presence of the Engineer. If the Contractor casts cylinders to represent more than one girder, all girders represented by the cast cylinders shall be cored and tested. A test shall consist of three cores from a girder measuring 4 inches in diameter by the thickness of the web and shall be removed from just below the top flange. One core shall be taken at the midpoint of the girder's length and the other two cores shall be taken approximately 3 feet to the left and approximately 3 feet to the right of the midpoint core. The cores shall be taken in accordance with AASHTO T 24 and shall be tested in accordance with AASHTO T 22. The Engineer may accept a girder if the average compressive strength of three cores from that girder is at least 85 percent of the specified compressive strength with no one core less than 75 percent of specified compressive strength.

If the girder is cored to determine the release strength, the required patching and curing of the patch shall be done prior to shipment. If there are more than three holes or if they are not in a neutral location, the prestress steel shall not be released until the holes are patched and the patch material has attained a minimum compressive strength equal to the required release compressive strength or 4000 psi, whichever is less.

The Contractor shall coat cored holes with a Type II, Grade 2 epoxy and patch the holes using the same type concrete as that in the girder, or a concrete mix approved during WSDOT's annual plant review and approval process. The girder shall not be shipped until tests show the patch material has attained a minimum compressive strength of 4000 psi.

6-02.3(25)G PRESTRESS RELEASE

Side and flange forms that restrain deflection shall be removed before release of the prestressing reinforcement.

All harped and straight strands shall be released in a way that produces the least possible tension in the concrete. This release shall not occur until test results show each girder has reached the minimum Contract specified strength.

6-02.3(25)H PROTECTION OF EXPOSED REINFORCEMENT

See Section 6-02.3(25)A for protection of reinforcement requirements. When a girder is removed from its casting bed, all bars and strands projecting from the girder shall be cleaned and painted with a minimum dry film thickness of 1 mil of paint Formula No. A-9-73 (Section 9-08). During handling and shipping, projecting reinforcement shall be protected from bending or breaking. The Contractor shall remove all dirt, oil, and other contaminants from the painted projected reinforcing before placing concrete.

6-02.3(25)I FINISHING

The Contractor shall apply a Class 2 finish, as defined in Section 6-02.3(14), to:

1. The vertical exterior surfaces of the outside girders;
2. The bottoms, sides, and tops of the lower flanges on all girders; and
3. The bottom of the outside roadway flange of each outside bulb tee girder section.

All other girder surfaces shall receive a Class 3 finish.

The interface on I-girders and other girders that contact the cast-in-place deck shall have a finish of dense, screeded concrete. The finished surface shall not have a smooth sheen or laitance. The Contractor shall texture the interface after vibrating and screeding, but just before the concrete reaches initial set. This surface texture shall be transverse grooves 1/8-inch to 1/4-inch wide, between 1/8-inch and 1/4-inch deep, and spaced 1/4-inch to 1/2-inch apart.

On the deck bulb tee girder section, the Contractor shall test the roadway deck surface portion for flatness. This test shall occur after floating but while the concrete remains plastic. Testing shall be done with a 10-foot-straightedge parallel to the girder centerline and with a flange width straightedge at right angles to the girder centerline. The Contractor shall fill depressions, cut down high spots, and refinish to correct any deviation of more than 1/4 inch within the straightedge length. This section of the roadway surface shall be finished to meet the requirements for finishing roadway slabs, as defined in Section 6-02.3(10).

The Contractor may repair rock pockets and other defects in the girder provided the repair is covered in WSDOT's annual plant approval package. All other repairs and repair procedures shall be documented and reviewed by the Engineer prior to acceptance of the girder.

6-02.3(25)J TOLERANCES

The girders shall be fabricated as indicated on the Drawings, and shall meet the following dimensional tolerances unless specified otherwise in the Contract. Actual acceptance or rejection will depend on whether a defect outside these tolerances affects the structure's specified strength or specified appearance:

1. Length (overall): ±1/4 inch per 25 feet of beam length, up to a maximum of ±1 inch.
2. Width (flanges): + 3/8 inch, - 1/4 inch.
3. Width (narrow web section): + 3/8 inch, - 1/4 inch.
4. Girder Depth (overall): ±1/4 inch.
5. Flange Depth: + 1/4, - 1/8 inch.
6. Strand Position: ±1/4 inch from center of gravity of the strand group and individual strands.
7. Longitudinal Position of Harping Points: ±18 inches.
8. Bearing Recess (center recess to end beam): ±1/4 inch.
9. Beam Ends (deviation from square or designated skew)

Horizontal: ±1/2 inch from web centerline to flange edge
Vertical: ±1/8 inch per foot of beam depth.

10. Bearing Area Deviation from Plane (in length or width of bearing): 1/16 inch.
11. Stirrup Reinforcing Spacing: ±1 inch.
12. Stirrup Projection from Top of Beam: ±3/4 inch.
13. Mild Steel Concrete Cover: - 1/8 inch, + 3/8 inch.
14. Offset at Form Joints (deviation from a straight line extending 5 feet on each side of joint): ±1/4 inch.
15. Differential Camber Between Girders in a Span (measured in place at the job site)
    a. For I-girders: 1/8 inch per 10 feet of beam length (series W42G, W50G, W58G, and W74G)
    b. For bulb tee girders: Cambers shall be equalized by a method submitted to and reviewed by the Engineer when the difference in cambers between adjacent girders or stages measured at mid-span exceeds 1/4 inch.
16. Position of Inserts for Structural Connections: ±1/2 inch.
17. Position of Lifting Loops: ± 3 inches longitudinal, ±1 inch transverse.
18. Weld plates for bulb tee girders shall be placed ±1/2 inch longitudinal, and ±1/8 inch vertical.

6-02.3(25)K HORIZONTAL ALIGNMENT

The Contractor shall check and record the horizontal alignment of both top and bottom flanges of each girder upon removal from the casting bed. The Contractor shall also check and record the horizontal alignment within a two week period prior to shipment, but no less than three days prior to shipment. If the girder remains in storage for a period exceeding 120 days, the Contractor shall check and record the horizontal alignment at approximately 120 days. Each check shall be made by measuring the distance between each flange and a chord that extends the full length of the girder. The Contractor shall perform and record each check at a time when the alignment of the girder is not influenced by temporary differences in surface temperature. These records shall be available for the Engineer's review and shall be included in the Contractor's Prestressed Concrete Certificate of Compliance.

Immediately after the girder is removed from the casting bed, neither flange shall be offset more than 1/8 inch for each 10 feet of girder length. During storage and prior to shipping, the offset (with girder ends plumb and upright and with no external force) shall not exceed 1/4 inch per 10 feet of girder length. Any girder within this tolerance may be shipped, but shall be corrected at the job site to the 1/8 inch maximum offset per 10 feet of girder length before concrete is placed into the diaphragms.

The Engineer may permit the use of external force to correct girder alignment at the plant or at the Project Site if the Contractor submits to the Engineer for review stress calculations and a proposed procedure indicating the expected girder correction. If external force is permitted, it shall not be released until after the roadway slab has been placed and cured ten days.

The Engineer may reject any girder that does not meet the requirements of this Specification Section.

6-02.3(25)L GIRDER DEFLECTION

The Contractor shall check and record the vertical deflection (camber) of the girder upon removal of the girder from the casting bed. If the girder remains in storage for a period exceeding 120 days, the Contractor shall check and record the vertical deflection (camber) within a two week period prior to shipment, but no less than three days prior to shipment. The Contractor shall perform and record each check at a time when the alignment of the girder is not influenced by temporary differences in surface temperature. These records shall be available for the Engineer's inspection, and in the case of girders older than 120 days, shall be transmitted to the Engineer as soon as practical for evaluation of the effect of long term storage on the "D" dimension. These records shall also be included in the Contractor's Prestressed Concrete Certificate of Compliance.

The "D" dimensions shown on the Drawings are computed girder deflections at midspan based on a time elapse of 120 days after release of the prestressing strands. A positive (+) "D" dimension indicates upward deflection.

The Contractor shall control the deflection of prestressed concrete girders that are to receive a cast-in-place slab by scheduling fabrication within 120 days of girder erection. If it is anticipated that the girders are to be older than 120 days at the time of erection, the Contractor shall submit calculations to the Engineer showing estimated girder deflection at midspan for the age anticipated for erection. This submittal shall also include the Contractor's proposal for accommodating any excess camber in the construction. The Contractor shall not proceed with girder fabrication until the submittal is reviewed and returned by the Engineer. The actual girder deflection at the midspan may vary from the "D" dimension at the time of slab forming by a maximum of plus 1/2 inch for girder lengths up to 80 feet, and plus 1 inch for girder lengths over 80 feet, but less than or equal to 140 feet, and plus 1½ inches for girder lengths over 140 feet.

All costs, including any additional Owner engineering expenses, in connection with accommodating excess girder deflection shall be at the Contractor's sole expense with no additional cost to the Owner.

6-02.3(25)M HANDLING AND STORAGE

Each girder shall be kept plumb and upright during handling and storage. It shall be lifted only by the lifting strands at either end. Series W42G, W50G and W58G girders can be lifted at an angle not to exceed 30 degrees to the vertical as measured in the longitudinal plane of the girder. All other prestressed girders shall be picked up vertically. Girders shall be braced laterally to prevent tipping or buckling as specified on the Drawings.

Before moving a long girder, the Contractor shall check it for any tendency to buckle. Each girder that may buckle shall be braced on the sides to prevent buckling. This bracing shall be attached securely to the top flange of the girder. The lateral bracing shall be in place during all lifting or handling necessary for transportation from the manufacturing plant to the Project Site and erection of the girder. The Contractor is cautioned that for some delivery routes more conservative guidelines for lateral bracing may be required. The Contractor shall ensure all girders are fastened in-place before removing the bracing to cast diaphragms.

If the Contractor wishes to deviate from these handling and bracing requirements, the vertical pickup, or the pickup location, the proposed method shall be analyzed by the Contractor's engineer and submitted with the supporting calculations to the Engineer for review. The Contractor's analysis shall conform to Articles 5.2 and 5.3 of the P.C.I. Design Handbook, Precast and Prestressed Concrete, Third Edition, or other approved methods. The Contractor's calculations shall verify that the concrete stresses in the prestressed girder do not exceed those listed in Section 6-02.3(25)N. All costs associated with the Contractor's deviation shall be at no additional cost to the Owner.

If girders are to be stored, the Contractor shall place them on a stable foundation that keeps them in a vertical position. Stored girders shall be supported at the bearing recesses, or approximately 18 inches from the girder ends if there are no recesses. For long-term storage of girders with initial horizontal curvature, the Contractor may wedge one side of the bottom flange, tilting the girders to control curvature. If the Contractor elects to set girders out of plumb during storage, the Contractor shall have the proposed method analyzed b y the Contractor's engineer to ensure against damaging the girder.

6-02.3(25)N SHIPPING

After the girder has reached its 28 day design strength, the Contractor shall obtain girder certification and then request the Engineer to accept the girder for approval to ship the girder. This approval will take the form of the Engineer stamping the girder "Approved for Shipment". To obtain girder certification, the fabricator shall present to the Engineer for inspection either:

1) a completed Manufacturer's Certificate of Compliance signed by a Prestressed Concrete Institute Certified Technician, certifying the girder complies with the Contract, or
2) certification from a professional engineer registered as a structural engineer in the State of Washington under Title 18 RCW who is acceptable to the Engineer, certifying the girder complies with the Contract.

If the Engineer finds the girder certification and the girder to be acceptable, the Engineer will stamp the girder "Approved for Shipment".

No prestressed girders shall be shipped that are not stamped "Approved for Shipment".

No bulb tee girder shall be shipped for at least seven days after concrete placement. No other girder shall be shipped for at least ten days after concrete placement.

Girder support during shipping shall meet these requirements unless otherwise specified in the Contract:

Type of Girder	Centerline Support Within This Distance From Either End
Series W42G and W50G, and all bulb tee girders	3 feet
Series W58G	4 feet
Series W74G	5 feet
Series W83G and W95G	8 feet

If the Contractor wishes to use other support locations, they shall be submitted to the Engineer for review. The Contractor's proposal shall comply with Section 6-02.3(25)M and shall include calculations showing concrete stresses in the girders shall not exceed the following:

Criteria for Checking Girder Stresses at the Time of Lifting or Transporting and Erecting

Stresses at both support and harping points shall be calculated based on the following:

1. Allowable compression stress, $f_c = 0.60\ f'_{cm}$.
   a. f'_{cm} = compressive strength at time of lifting or transporting verified by test but shall not exceed design compressive strength (f'_c) at 28 days in psi + 1,000 psi.
2. Allowable tension stress, ksi.
   a. With no bonded reinforcement = 3 times the square root of f'_{cm}.
   b. With bonded reinforcement to resist total tension force in the concrete computed on the basis of an uncracked section = 7.5 times the square root of f'_{cm}. The allowable tensile stress in reinforcement is 30 ksi (ASSHTO M 31, Gr. 60).
3. Prestress losses
   a. 1 day to 1 month = 20,000 psi
   b. 1 month to 1 year = 35,000 psi
   c. 1 year or more = 45,000 psi (max.)
4. Impact on dead load
   a. Lifting from casting beds = 0%
   b. Transporting and erecting = 20%

6-02.3(25)O PRESTRESS CONCRETE GIRDER ERECTION

The Contractor shall submit an erection plan to the Engineer for review. Before beginning to erect any prestressed concrete girders, the Contractor shall have received the Engineer reviewed erection plan and procedure submittal. The erection plan and procedure shall provide complete details of the erection process and methods including but not limited to:

1. Temporary falsework support, bracing, guys, deadmen, and attachments to other structure components or objects;
2. Procedure and sequence of operation;
3. Girder stresses during progressive stages of erection;
4. Girder weights, lift points, and lifting devices, spreaders, and angle of lifting cables in accordance with Section 6-02.3(25)M, etc.;
5. Crane(s) make and model, mass, geometry, lift capacity, outrigger size and reactions;
6. Girder launcher or trolley details and capacity (if intended for use); and
7. Locations of cranes, barges, trucks delivering girders, and the location of cranes and outriggers relative to other structures, including retaining walls and wing walls.

The erection plan shall include Shop Drawings, notes, catalog cuts, and calculations clearly showing the above listed details, assumptions, and dimensions. Material properties and specifications, structural analysis, and any other data used shall also be included. The erection plan shall be prepared by a professional engineer in accordance with Section 1-05.3(12).

The Contractor shall submit the erection Shop Drawings, calculations, and procedure directly to the Engineer, in accordance with Section 6-02.3(16). After the Shop Drawings is reviewed and returned to the Contractor, all subsequent changes that the Contractor proposes to the Engineer reviewed and returned submittal shall be resubmitted to the Engineer for additional review. The resubmitted Shop Drawings shall clearly note the changes from the reviewed and returned Shop Drawings along with supporting calculations.

When prestressed girders arrive on the Project Site, the Engineer will confirm that they are stamped “Approved for Shipment” and that they have not been damaged in shipment before accepting them.

The concrete in piers and crossbeams shall reach at least 80 percent of design strength before girders are placed on them. The Contractor shall hoist girders only by the lifting strands at the ends, always keeping the girders plumb and upright.

Instead of the oak block wedges shown on the Drawings, the Contractor may use Douglas fir blocks if the grain is vertical.

Before the grout pads are placed, the receiving concrete shall be thoroughly cleaned, roughened, and wetted with water to ensure proper bonding. Grout pad requirements will be specified on the Drawings. Grout pads shall reach the specified strength before placing girders on them. The Materials Laboratory will determine grout compressive strength by fabricating cubes in accordance with WSDOT Test Method 813 and testing in accordance with AASHTO T 106. The Contractor shall provide the Engineer at least 2 Working Days advance notice.

The Contractor shall check the horizontal alignment of both the top and bottom flanges of each girder, as described in Section 6-02.3(25)K, before placing concrete in the bridge diaphragms.

The Contractor shall completely fill all block-out holes and restore any area damaged by the Contractor’s operation to its original or better condition with an approved grout mix at no additional cost to the Owner.

6-02.3(25)P DECK BULB TEE GIRDER FLANGE CONNECTION

The Contractor shall submit a method of equalizing deck bulb tee girder deflections to the Engineer for review. This submittal shall be prepared by a professional engineer in accordance with Section 1-05.3(12) and shall be made a minimum of 60 days prior to field erection of the deck bulb tee girder. On deck bulb tee girders, girder camber shall be equalized utilizing the submitted and reviewed method before girders are weld-tied and before keyways are filled. Keyways between tee girders shall be filled flush with the surrounding surfaces with non-shrink grout. This non-shrink grout shall have a compressive strength of 4,000 psi before the equalizing equipment is removed. The SPU Materials Laboratory will determine grout compressive strength by fabricating cubes in accordance with WSDOT Test Method 813 and testing in accordance with AASHTO T 106. The Contractor shall provide the Engineer at least 2 Working Days advance notice.

Welding grounds shall be attached directly to the steel plates being welded when welding the weld-ties on bulb tee girders.

No construction equipment shall be placed on the Structure, other than equalizing equipment, until the girders have been weld-tied and the keyway grout has attained a compressive strength of 4,000 psi.

6-02.3(26) CAST-IN-PLACE PRESTRESSED CONCRETE

6-02.3(26)A GENERAL

Cast-in-place prestressed concrete shall be Class 4000D, unless the Contract specifies otherwise. It shall be air-entrained, but shall not contain air-entraining cement.

The Contractor shall construct supporting falsework in a way that leaves the superstructure free to contract and lift off the falsework during post-tensioning. Forms that remain inside box girders to support the roadway slab shall, by design, resist girder contraction as little as possible.

Before tensioning, the Contractor shall remove all side forms from girders. From this point until 48 hours after grouting the tendons, the Contractor shall keep all construction and other live loads off the superstructure and shall keep the falsework supporting the superstructure in place.

Once the prestressing steel is installed, no welds or welding grounds shall be attached to metal forms, structural steel, or reinforcing bars of the structural member.

The Contractor shall not stress the strands until all concrete has reached a compressive strength of at least 4,000 psi (or the strength shown on the Drawings). This strength shall be measured on concrete test cylinders made of the same concrete cured under the same conditions as the cast-in-place unit.

All post-tensioning shall be completed before sidewalks and barriers are placed.

6-02.3(26)B SHOP DRAWINGS

Before casting the structural elements, the Contractor shall submit for review, in accordance with Section 6-02.3(16), complete details of the method, materials, and equipment he proposes to use in the prestressing operations.

In addition, the Shop Drawings shall show:

1. The method and sequence of stressing;
2. Technical data on tendons and steel reinforcement, anchoring devices, anchoring stresses, types of tendon conduit, and all other data on prestressing operations;
3. Separate stress and elongation calculations shall be submitted for each tendon if the difference in tendon elongations exceeds 2 percent;
4. That tendons in the bridge shall be arranged to locate their center of gravity as the Drawings require;
5. Details of additional or modified reinforcing steel required by the stressing system; and
6. Procedures and lift-off forces at both ends of the tendon for performing a force verification lift-off in the event of discrepancies between measured and calculated elongations.

Review of these Shop Drawings will mean only that the Engineer considers them to show a reasonable approach in enough detail. Review will not indicate a check on dimensions.

Couplings or splices will not be permitted in prestressing strands. The Contractor shall submit sketches and calculations of couplings or splices in bar tendons for the Engineer's review.

Friction losses used to calculate forces of the post-tensioning steel shall be based on the assumed values used for the design. The assumed anchor set, friction coefficient "μ" and friction wobble coefficient "k" values for design are shown on the Drawings. The post-tensioning Supplier may revise the assumed anchor set value provided all of the stress and force limits listed in Section 6-02.3(26)F are met.

The Contractor shall determine all points of interference between the mild steel reinforcement and the paths of the post-tensioning tendons. Details to resolve interferences shall be submitted with the Shop Drawings for review. Where reinforcing bar placement conflicts with post-tensioning tendon placement, the tendon profile shown on the Drawings shall be maintained. Mild steel reinforcement for post-tensioning anchorage zones shall not be fabricated until after the post-tensioning Shop Drawings have been reviewed by the Engineer.

The Contractor may deviate from the Engineer's reviewed Shop Drawings only after submitting a written request that describes the proposed changes and obtains the Engineer's written notice of review of the proposed changes. The Engineer's review of a change in method, material, or equipment shall not relieve the Contractor of any responsibility for successfully completing the work.

Before physical completion of the project, the Contractor shall provide the Engineer with reproducible originals of the Shop Drawings (and any Engineer reviewed changes). These shall be legible, clear, suitable for microfilming, and on permanent sheets of sizes specified in Section 1-05.3(10).

6-02.3(26)C ANCHORAGES

Post-tensioning reinforcement shall be secured at each end by means of an anchorage device which shall be of such a nature that it does not kink, neck down, or otherwise damage the post-tensioning reinforcement. The anchorage assembly shall be securely grouted.

The structure shall be reinforced with steel reinforcing bars in the vicinity of the anchorage device. This reinforcement is categorized into two zones. The first or local zone is the anchorage region that closely surrounds the specific anchorage device. The second or general zone is the portion of the anchorage region more remote from the anchorage device.

The steel reinforcing bars required locally for the concrete confinement immediately around the anchorage device (first or local zone) shall be calculated by the post-tensioning system Supplier and shall be shown in the Shop Drawings. The calculations shall be submitted with the Shop Drawings. The first or local zone steel reinforcing bars shall be furnished and installed by the Contractor, at no additional cost to the Owner, in addition to the structural reinforcement required by the Drawings. The steel reinforcing bars required in the second or general zone shall be as shown on the Drawings and are included in the appropriate Bid items.

The Contractor shall submit details, certified tests reports, and/or supporting calculations specified in the following, which verify the structural adequacy of the anchorage devices for review by the Engineer. This requirement does not apply where the anchorage devices have been previously approved by the Engineer for the same structure configuration. The Contractor shall also submit any necessary changes to the Contract. The test report shall specify all pertinent test data. Dead ended anchorages will not be permitted. Dead ended anchorages are defined as anchorages that cannot be accessed during the stressing operations.

The Contractor's proposed anchorage devices shall meet the requirements listed either in 1, bearing type anchorage, or 2, other anchorage assemblies, as follows:

1. **Bearing Type Anchorage**:
   a. The computed average bearing stress on the concrete directly beneath bearing plates shall not exceed either of the following:
      (1) At service load (after all losses)
      $f_{cp} =$ $0.6\, f'_c\, (A'b/Ab)^{1/2}$ but not greater than $1.25\, f'_c$.
      (2) At jacking load (before seating)
      $f_{cp} =$ $0.8\, f'_{ci}\, (A'b/Ab - 0.2)^{1/2}$ but not greater than $1.25\, f'_{ci}$ for longitudinal tendons anchored in the webs and not greater than $1.00\, f'_{ci}$ for transverse tendons anchored in the deck slab, where:

      $f_{cp} =$ permissible compressive concrete stress,
      $f'_c =$ compressive strength of concrete,
      $f'_{ci} =$ compressive strength of concrete at time of initial prestress,
      $A'b =$ Maximum area of the portion of the concrete anchorage surface that is geometrically similar to and concentric with the area of the anchorage (excluding openings),
      $Ab =$ bearing area of the anchorage excluding openings.
   b. For anchorages where $A'b$ and Ab are equal, and in transverse post-tensioning of roadway slabs, the bearing stress shall not exceed $0.9f'_c$ at jacking load (before seating) or 3000 psi at service load after all losses.
   c. The computed bending stresses in the distribution plate induced by the pull of the prestressing steel shall not exceed 90 percent of the yield point of the material when 95 percent of the ultimate strength of the post-tensioning reinforcement is applied. The bending stresses in the distribution plate shall be computed in accordance with the procedure described in the article titled, "Simplified Bearing Plate Computations for Post-Tensioning Anchorages" published in the July-August 1975 edition of the PCI Journal. These calculations shall be submitted with the Shop Drawings for review.
   d. Materials and workmanship shall conform to the applicable requirements of Sections 6-03 and 9-06.
2. **Other Anchorage Assemblies**:
   Other anchorage assemblies shall be defined as any assembly that does not meet the requirements of item 1.a. above for bearing-type anchorages. The adequacy of other anchorage assemblies shall be demonstrated by tests representing actual job site conditions. The tests shall be certified and meet the following requirements:
   a. The concrete test block shall have a cross-section equal to twice the minimum edge distance of center line of tendon to the face of concrete in the actual structure in one direction and equal to the minimum spacing of the anchorages plus 3 inches in the other direction. The length of the concrete test block shall be at least three times the largest cross-sectional dimension.
   b. The reinforcement in the test block behind the anchorage for a distance equal to the largest of the two cross-sectional dimensions of the anchorage shall simulate the actual reinforcement used in the structure. For the remaining length of the test block, the reinforcement may be increased as required to prevent failure in that portion.
   c. Concrete strength at the time of testing shall not exceed 85 percent of the minimum concrete strength at the time of post-tensioning as specified in the Contract. The concrete strength shall be determined in accordance with procedures outlined in ASTM C 1074, Estimating Concrete Strength by the Maturity Method.
   d. The test shall be comprised of three anchorages separately tested or tested together in one test block.
   e. Anchorages shall be Capable of developing 95 percent of the ultimate strength of the post-tensioning reinforcement without measurable permanent distortion of the assembly and without concrete failure in the test block. Measurable permanent distortion is defined as a distortion across the face of the assembly of 0.01 inch or more using the original plane as a reference and is measured after the test loading is released. Test blocks that comply with the following criteria shall be acceptable with regard to concrete failure:
      (1) No concrete cracks with a load of 40 percent of the ultimate strength of the post-tensioning reinforcement.
      (2) Width of concrete cracks with a test load of 70 percent of the ultimate strength of the post-tensioning reinforcement does not exceed 0.005 inch.
      (3) After loading to 95 percent of the ultimate strength of the post-tensioning reinforcement and releasing the test load, the width of concrete cracks does not exceed 0.015 inch.
   f. Materials and workmanship shall conform to the applicable requirements of Sections 6-03 and 9-06.

The Contractor shall submit a Manufacturer's Certificate of Compliance for the anchorage device in accordance with Section 1-06.3 before installing the anchorage device.

6-02.3(26)D METAL DUCTS

The Contractor shall encase each tendon in a galvanized, rigid, spiral, ferrous metal duct. This duct shall maintain the required profile within a placement tolerance of ±1/4-inch for longitudinal tendons and ±1/8-inch for transverse slab tendons, during all phases of the work. The conduit shall be completely sealed to keep out all mortar.

Each conduit shall be located to place the tendon at the center of gravity as indicated on the Drawings. To keep friction losses to a minimum, the Contractor shall install duct to the exact lines and grades shown on the Drawings. Once in place, the duct shall be tied firmly in position before they are covered with concrete. During concrete placement, the duct shall not be displaced or damaged.

The ends of the duct shall:

1. Permit free movement of anchorage devices, and
2. Remain covered after installation in the forms to keep out all water or debris.

The Contractor shall install vents at high points and drains at low points of the tendon profile and at other places as indicated on the Drawings. Vents and drains shall be 1/2-inch minimum diameter standard steel or polyethylene pipe. Vents shall point upward and remain closed until grouting begins. Drains shall point downward and remain open until grouting begins. Ends of steel vents and drains shall be removed to a depth of 1 inch inside the concrete surface after grouting has been completed. Polyethylene vents and drains may be left flush to the surface unless the Contract indicates otherwise. Duct vents are not required for transverse post-tensioning ducts in the roadway slab unless otherwise specified in the Contract.

Immediately after any concrete placement, the Contractor shall force blasts of oil-free, compressed air through the duct to break up and remove any concrete inside before it hardens. Before deck concrete is placed, the Contractor shall first verify that the ducts are unobstructed and contain nothing that could interfere with grouting or harm the tendons, and second, provide written verification to the Engineer before placing concrete that this inspection has taken place. If the tendons are in place, the Contractor shall show that they are free in the duct.

Ducts shall be kept free from water.

6-02.3(26)E PRESTRESSING REINFORCEMENT

All prestressing reinforcement shall comply with Section 9-07.10. They shall not be coupled or spliced. Tendon locations shown on the Drawings indicate final positions after stressing (unless the Contract specifies otherwise). No tendon made of 7-wire strands shall contain more than 31 strands of 1/2-inch diameter, or more than 22 strands of 0.6-inch diameter.

From the time prestressing reinforcement is made until it is grouted or encased in concrete, the Contractor shall protect it from contaminants including but not limited to dirt, grease, rust, corrosives, and any physical damage. The Engineer will reject prestressing reinforcement that is damaged or contaminated. If the prestressing reinforcement is not to be stressed and grouted within 10 calendar days after it is placed in the conduits, the Contractor shall place an approved corrosion inhibitor in the conduits.

The feeding ends of the strands shall be equipped with a bullet nosing or similar apparatus to facilitate strand installation.

6-02.3(26)F TENSIONING

The Contractor shall not begin to tension the tendons until:

1. All concrete has reached a minimum compressive strength of 4,000 psi or the strength indicated in the Contract as demonstrated on test cylinders made of the same concrete and cured under the same conditions as that in the bridge; and
2. The strands and ducts comply with specified requirements.

Tendons shall be tensioned to the values shown in the Contract using hydraulic jacks unless the Shop Drawings clearly indicate a different tension value with explanation and supporting calculations for the Engineer's Shop Drawing review. When stressing from both ends of a tendon is specified, it need not be simultaneous unless indicated otherwise in the Contract. The jacking sequence shall comply with the reviewed Shop Drawings.

Each jack shall have a pressure gauge that indicates the load applied to the tendon. The gauge shall display pressure accurately and readably with a dial at least 6 inches in diameter or with a digital display. Each jack and its gauge shall be calibrated as a unit and shall be accompanied by a certified calibration chart. The calibration and certification shall be obtained from an AASHTO certified testing laboratory acceptable to the Engineer. The Contractor shall provide one copy of this chart to the Engineer for use in monitoring. The cylinder extension during calibration shall be in approximately the position it is to occupy at final jacking force.

All jacks and gauges shall be recalibrated and recertified:

(1) at least every 180 days, and

(2) after any repair or adjustment.

The Engineer may use pressure cells to check jacks, gauges, and calibration charts before and during tensioning.

These stress limits apply to all tendons, unless the Contract specifies other limits:

1)	Maximum service load after all losses:	80 percent of the specified yield stress of the steel.
2)	Maximum tensile strength during jacking:	79 percent of the specified minimum ultimate tensile strength of the steel.
3)	Maximum initial stress at anchoring after seating:	70 percent of the specified minimum ultimate

tensile strength of the steel.

Tendons shall be anchored at initial stresses that ultimately maintain service loads at least as great as indicated on the Drawings.

As tensioning proceeds, in the presence of the Engineer the Contractor shall record the applied load, tendon elongation, and anchorage seating values.

As stated in Section 6-02.3(26)B, the assumed design friction coefficient "μ" and wobble coefficient "k" specified in the Contract shall be used to calculate the stressing elongation. These coefficients may be revised by the post-tensioning Supplier by the following method provided the Contractor submits this revision in advance to the Engineer for review:

(1) Before fabrication and in the presence of the Engineer, the post-tensioning Supplier shall test, in place, two representative tendons of each size and type shown on the Drawings, for the purpose of accurately determining the friction loss in the strand and/or bar tendon.

(2) The test procedure shall consist of stressing the tendon at an anchor assembly with load cells at the dead end and jacking end. The test specimen shall be tensioned to 79 percent of ultimate strength in ten increments. For each increment, the gauge pressure, elongation, and load cell force shall be recorded and the data furnished to the Engineer. The theoretical elongations and post-tensioning forces shown on the post-tensioning Shop Drawings shall be re-evaluated by the post-tensioning Supplier using the results of the tests and corrected as necessary. Revisions to the theoretical elongations shall be submitted to the Engineer for evaluation and review. Details of the apparatus and methods used to perform the tests shall be proposed by the post-tensioning Supplier and shall be submitted through the Contractor to the Engineer.

As tensioning proceeds and in the presence of the Engineer, the Contractor shall record the applied load, tendon elongation, and anchorage seating values.

Elongation measurements shall be made at each stressing location to verify that the tendon force has been properly achieved. If proper anchor set has been achieved and the measured elongation of each strand tendon is within ±7 percent of the submitted and reviewed calculated elongation, the stressed tendon represented by the elongation measurements is acceptable to the Engineer.

In the event discrepancies greater than 7 percent exist between the measured and calculated elongations, the jack calibration shall be checked and stressing records reviewed for any evidence of wire or strand breakage. If the jack is properly calibrated and there is no evidence of wire or strand breakage, a force verification lift-off shall be performed to verify the force in the tendon. The post-tensioning Supplier force verification lift-off procedure shall provide access for visual verification of anchor plate lift-off. The jacking equipment shall be Capable of bridging and lifting off the anchor plate. The tendon is acceptable if the verification lift-off force is not less than 99 percent of the submitted and reviewed calculated force nor more than 70 percent of the specified minimum ultimate tensile strength of the prestressing steel unless the Contract specifies otherwise.

Elongation measurements shall be recorded for bar tendons to verify proper tensioning only. Acceptance will be by force verification lift-off. The bar tendon is acceptable if the verification lift-off force is not less than 95 percent nor more than 105 percent of the submitted and reviewed calculated force unless the Contract specifies otherwise.

When removing the jacks, the Contractor shall relieve stresses gradually before cutting the prestressing reinforcement. The prestressing strands shall be cut a minimum of 1 inch from the face of the anchorage device.

6-02.3(26)G GROUTING

After tensioning the tendons, the Contractor shall again blow oil-free, compressed air through each duct. All drains shall then be closed and the vents opened. After completely filling the duct with grout, the Contractor shall pump the grout from the low end at a pressure of not more than 250 psig, except for transverse tendons in deck slabs the grout pressure shall not exceed 100 psig. Grout shall be continuously wasted through the vent until no more air or water pockets show. At this point, all vents shall be closed and grouting pressure at the injector held between 100 and 200 psig for at least 10 seconds, except for transverse tendons in deck slabs the grouting pressure shall be held between 50 and 75 psig for at least 10 seconds. The Contractor shall leave all plugs, caps, and valves in place and closed for at least 24 hours after grouting.

Grouting equipment shall:

1. Include a pressure gauge with an upper end readout in the range of 275 to 325 psig;
2. Screen the grout before it enters the pump with an easily reached screen that has clear openings of no more than 0.125 inches;
3. Be gravity fed from an attached, overhead hopper kept partly full during pumping; and
4. Be able to complete the largest tendon on the project in no more than 20 minutes of continuous grouting.

In addition, the Contractor shall take steps necessary to ensure a continuous, one-way flow of grout is maintained. These steps may include but are not limited to having standby equipment able to pump at 250 psig, having a separate power source, and being readily available for flushing when the regular equipment cannot maintain a one-way flow of grout.

The grout shall consist of Portland cement, water, and a water reducing admixture and shall be mixed in the following proportions:

Portland Cement Type II	1 Sack
Water	4.5 Gallons Maximum
Water Reducing Admixture	Manufacturer's Recommendation
Fly Ash (Optional)	20 Pounds Maximum

The water reducing admixture shall be limited to AASHTO M 194, Type A or Type D, and shall not contain ingredients that may corrode steel, such as chlorides, fluorides, sulfates, or nitrates. Fly ash may be used at the option of the Contractor.

The Contractor shall proportion the mix to produce a grout with a minimum flow time of 15 seconds to a maximum flow time of 20 seconds as determined by ASTM C 939, Flow of Grout for Preplaced Aggregate Concrete (Flow Cone Method).

The grout mix shall be injected within 30 minutes after the water is added to the cement. The Contractor shall take steps to ensure the temperature of the surrounding concrete is maintained at least 35°F from the time the grout injecting begins until at least 2 of the 2 inch cube samples of the grout indicates a compressive strength of 800 psi. Cubes shall be samples in accordance with WSDOT Test Method 813 and stored in accordance with method 2 of WSDOT Test Method 809. If the surrounding concrete temperature may fall below 35°F, the Contractor shall be prepared to provide a heat source and protective covering to maintain the temperature of the surrounding concrete above 35°F. Grout temperature shall not exceed 90°F during mixing and pumping. If conditions are such that the temperature of the grout mix may exceed 90°F, the Contractor shall make necessary provisions, such as cooling the mix water and/or dry ingredients, to ensure that the temperature of the grout mix does not exceed 90°F.

6-02.3(27) CONCRETE FOR PRECAST UNITS

Precast units shall not be removed from forms until the concrete has attained a minimum compressive strength of 70 percent of the specified design strength as verified by rebound number determined in accordance with ASTM C 805.

Precast units shall not be shipped until the concrete has reached the specified design strength as determined by testing cylinders made from the same concrete as the precast units. The cylinders shall be made, handled, and stored in accordance with Field Operating Procedure for AASHTO T 23, Method 2, and compression tested in accordance with AASHTO T 22 and AASHTO T 231.

6-02.3(28) PRECAST CONCRETE PANELS

6-02.3(28)A GENERAL

The Contractor shall perform quality control inspection. The manufacturing plant for precast concrete units shall be certified by the Precast/Prestressed Concrete Institute's (P/PCI) Plant Certification Program for the type of precast member to be produced. Proof of plant certification by P/PCI shall be submitted along with the Shop Drawings by the Contractor to the Engineer. Products that conform to this requirement include noise barrier panels, wall panels, floor and roof panels, marine pier deck panels, retaining walls, pier caps, and bridge deck panels.

Prior to the start of production of the precast concrete units, the Contractor shall give the Engineer advance notice of the production schedule. The Contractor shall give the Inspector safe and free access to the work. If the Inspector observes any nonspecification work or unacceptable quality control practices, the Inspector will inform the plant manager. If the corrective action is not acceptable to the Engineer, the unit(s) will be rejected.

The Engineer intends to perform Quality Assurance inspection. By its inspection, the Engineer intends only to facilitate the work and verify the quality of that work. This inspection shall not relieve the Contractor of any responsibility for identifying and replacing defective material and workmanship.

If products are prestressed, all prestressing materials and methods shall be in accordance with Section 6-02.3(25).

6-02.3(28)B SHOP DRAWINGS

The Contractor shall submit Shop Drawings of Precast/Prestressed Panels as specified in Section 1-05.3(10).

Shop Drawings shall show complete details of the methods, materials, and equipment the Contractor proposes to use in prestressing/precasting work. The Shop Drawings shall follow the design conditions shown on the Drawings unless variations are submitted and reviewed by the Engineer.

The Shop Drawings shall contain as a minimum:

1. Unit shapes (elevations and sections), and dimensions;
2. Finishes and method of constructing the finish (i.e., forming, rolling, etc.);
3. Reinforcing, joint and connection details;
4. Lifting, bracing and erection inserts;
5. Locations and details of hardware attached to the structure; and
6. Relationship to adjacent material.

The Contractor may deviate from the submitted and reviewed Shop Drawings only after obtaining the Engineer's review of a written notice that describes the proposed changes to the prior reviewed Shop Drawings.

Before physical completion can be established, the Contractor shall provide the Engineer with reproducible originals of the Shop Drawings (and any changes which were submitted to the Engineer for review). These shall be clear, suitable for microfilming, and on permanent sheets of sizes specified in Section 1-05.3(10).

6-02.3(28)C CASTING

The Contractor and Fabrication Inspector shall have in their possession, an Engineer reviewed set of Shop Drawings before casting precast concrete units.

Precast units shall not be removed from forms until the concrete has attained a minimum compressive strength of 70 percent of the specified design strength.

Forms may be either steel or plywood faced provided they impart the required finish to the concrete.

6-02.3(28)D CURING

Concrete in the precast units shall be cured by either moist or accelerated curing methods. The method to be used shall be preapproved in the annual WSDOT plant certification process.

1. For moist curing, the surface of the concrete shall be kept covered or moist until such time as the compressive strength of the concrete reaches the strength specified for stripping. Exposed surfaces shall be kept continually moist by fogging, spraying or covering with moist burlap or cotton mats. Moist curing shall commence as soon as possible following completion of surface finishing.
2. For accelerated curing, heat shall be applied at a controlled rate following the initial set of concrete in combination with an effective method of supplying or retaining moisture. Moisture may be applied by a cover of moist burlap, cotton matting, or other effective means. Moisture may be retained by covering the unit with an impermeable sheet.

Heat may be radiant, convection, conducted steam or hot air. Heat the concrete to no more than 100°F during the first two hours after placing the concrete, and then increase the temperature at a rate not to exceed 25°F per hour to a maximum of 175°F. After curing is complete, cool the concrete at a rate not to exceed 25°F per hour to 100°F. Maintain the concrete temperature above 60°F until the unit reaches stripping strength.

Concrete temperature shall be monitored by means of a thermocouple embedded in the concrete (linked with a thermometer accurate to ±5 F°). The recording sensor (accurate to ±5 F°) shall be arranged and calibrated to continuously record, date, and identify concrete temperature throughout the heating cycle. This temperature record shall be made available to the Engineer and become a part of the documentation required.

The Contractor shall never allow dry heat to make direct contact with exposed concrete surfaces at any point.

6-02.3(28)E CONTRACTORS CONTROL STRENGTH

The concrete strength at stripping shall be determined by testing cylinders made from the same concrete as the precast units. The cylinders shall be made, handled, and stored in accordance with Field Operating Procedure AASHTO T 23, Method 2, and compression tested in accordance with AASHTO T 22 and AASHTO T 231.

For accelerated cure units, concrete strength shall be measured on test cylinders cast from the same concrete as that in the unit. These cylinders shall be cured under time-temperature relationships and conditions that simulate those of the unit. If the forms are heated by steam or hot air, test cylinders shall remain in the coolest zone throughout curing. If forms are heated another way, the Contractor shall provide a record of the curing time-temperature relationship for the cylinders for each unit to the Engineer. When two or more units are cast in a continuous line and in a continuous pour, a single set of test cylinders may represent all units provided the Contractor demonstrates acceptable uniformity of casting and curing to the Engineer.

The Contractor shall mold, cure, and test enough of these cylinders to comply with specification requirements for measuring concrete strength. The Contractor may use 4-inch by 8-inch or 6-inch by 12-inch cylinders. The required design strength shall be increased 5 percent when using 4-inch by 8-inch cylinders. This 5 percent increase shall not be applied for the determination of the stripping strength. The Contractor shall let cylinders cool for at least one-half hour before testing for release strength.

Test cylinders may be cured in a moist room or water tank in accordance with AASHTO T 23 after the unit concrete has obtained the required release strength. If, however, the Contractor intends to ship the unit prior to the standard 28-day strength test, the design strength for shipping shall be determined from cylinders placed with the unit and cured under the same conditions as the unit. These cylinders may be placed in a noninsulated, moisture-proof envelope.

To measure concrete strength in the precast unit, the Contractor shall randomly select two test cylinders and average their compressive strengths. The compressive strength in either cylinder shall not fall more than 5 percent below the specified strength. If these two cylinders do not pass the test, two other cylinders shall be selected and tested.

6-02.3(28)F FINISHING

The Contractor shall provide a finish on all relevant concrete surfaces as defined in Section 6-02.3(14), unless the Contract requires otherwise.

6-02.3(28)G TOLERANCES

The units shall be fabricated as shown in the Contract, and shall meet the dimensional tolerances listed in P/PCI MNL-116-85, unless otherwise indicated in the Contract.

6-02.3(28)H HANDLING AND STORAGE

The Contractor shall lift all units only by adequate devices at locations designated on the Shop Drawings. Section 6-02.3(25)M shall apply when these devises and locations are not shown on the Drawings.

Precast unit shall be stored off the ground on foundations suitable to prevent differential settlement or twisting of the units. Stacked units shall be separated by dunnage of uniform thickness Capable of supporting the units. Dunnage shall be arranged in vertical planes. The upper units of a stacked tier shall not be used as storage areas for shorter units unless substantiated by engineering analysis and submitted to the Engineer for review.

6-02.3(28)I SHIPPING

Precast units shall not be shipped until the concrete has reached the design strength specified in the Contract. The units shall be supported in such a manner that they shall not be damaged by anticipated impact on their dead load during shipment. Tie chains and cables shall be padded to prevent chipping or spalling of the concrete.

6-02.3(28)J ERECTION

When the precast units arrive on the Project Site, the Engineer will confirm that they are stamped "Approved for Shipment". The Engineer will inspect the units for damage before accepting them.

The Contractor shall lift all units by suitable devices at locations designated on the Shop Drawings. Temporary shoring or bracing shall be provided, if necessary. Units shall be properly aligned and leveled as required by the Drawings. Variations between adjacent units shall be leveled out by a method submitted to and reviewed by the Engineer.

6-02.3(29) DOWNSPOUTS

The Contractor shall furnish and install standard weight steel pipe downspouts no less than 6 inch inside diameter at the locations shown and as detailed in the Contract.

The downspouts shall be full length pipe sections in all straight runs. The Contractor may propose types of couplings and fittings other than grooved couplings and fittings, provided they are equal performance and are included in the submittal specified in the last paragraph of this Section.

The portion of downspouts and/or drain pipe constructed within concrete shall be fully encased in a sponge rubber compound 1/2 inch thick and meeting the requirements of ASTM D 1752, Type No. 1, except the color requirement is waived.

All pipe bends, whether encased in concrete or not, shall have a bend radius of not less than 4 feet. All straight run pipe shall have a minimum slope of 10%. The Contractor shall verify all downspout lengths by field measurements prior to fabrication and shall determine the exact lengths of pipe and the hangers required for each bridge drain location.

The Contractor shall submit to the Engineer for approval at least 5 Working Days in advance of this work, Shop Drawings showing each downspout pipe layout including size of pipe(s), spacing and type of pipe hangers and concrete inserts, radius of bends, details of pipe connections including connection to receiving pipe or drainage Structure, slopes of straight run pipe, and connection to bridge drain details.

See Section 6-02.3(36) regarding bridge drains and clean outs.

6-02.3(30) DRILLING HOLES IN CONCRETE

The Contractor shall drill holes in the existing concrete facilities as located on the Drawings. The diameter of the hole shall be sized as recommended by the manufacturer of the bonding agent used for anchoring a new member in that hole.

The Contractor shall submit to the Engineer for approval, the bonding agent manufacturer's name, and recommendations for the bonding agent, instructions for use, recommended hole size for size bar to be epoxied, the method of drilling the hole, controls to prevent drilling beyond required penetration, and such other information as necessary at least 5 Working Days in advance of this work. If the bonding agent manufacturer has no recommended hole diameter for each diameter bar or rod, the manufacturer shall include a statement in the submittal certifying that the bonding agent bonds the bars or rods to the required hole diameters recommended as follows:

Diameter of Bar or Rod	Hole Diameter Required
Diameter Holes for #18 Bars	2-1/2"
Diameter Holes for #14 Bars	2"
Diameter Holes for #11 Bars	1-5/8"
Diameter Holes for #10 Bars	1-1/2"
Diameter Holes for # 9 Bars	1-3/8"
Diameter Holes for # 8 Bars	1-1/4"
Diameter Holes for # 7 Bars	1-1/8"
Diameter Holes for # 6 Bars	1"
Diameter Holes for # 5 Bars	3/4"
Diameter Holes for # 4 Bars	5/8"
Diameter Holes for # 3 Bars	1/2"
For threaded rod	1/4" larger than the outside diameter of the rod.

The holes to be drilled in the existing concrete shall be drilled with equipment that shall not fracture or damage the existing concrete which is to remain, or fracture the aggregate that surrounds the hole. Jackhammers shall not be used to drill holes. The method used to drill the holes shall provide a fracture free surface in which to epoxy bond the bars and/or threaded rods. The hole shall be roughened and cleaned prior to bonding bar or rod.

The Contractor shall not begin hole drilling operations until the method submitted is approved by the Engineer. Prior to drilling the hole, the Contractor shall locate reinforcement by a non destructive testing method. If existing steel reinforcing is hit during drilling, the drilling shall be immediately stopped and the Engineer shall be immediately notified. The rejected hole shall be cleaned and then filled completely with non-shrink grout per Section 9-04.3(2). After again locating reinforcement as described immediately above, a new hole shall be drilled adjacent to the rejected hole.

6-02.3(31) EPOXY IN DRILLED HOLES

Reinforcing bars or threaded rods shall be secured in holes drilled into existing concrete where indicated on the Drawings using a high strength, creep resistant epoxy resin meeting the requirements of Section 9-26. The epoxy system shall meet the requirements of ASTM C 881, Type 4, or approved equal performance. For products other than epoxy resins, the Contractor shall submit a Manufacturer's Certificate of Compliance including a test report from an independent testing laboratory, which complies with the requirements of ASTM E 1595, verifying that the application temperature range, cure time, heat deflection temperature (ASTM D 648), and slant shear strength (AASHTO T 237) are equal to or better than the above specified epoxy resin systems.

The Contractor shall place the reinforcing steel and/or threaded rods in existing concrete in the following manner:

1. Core drilled or other smooth surface holes shall be sandblasted full depth to roughen sides of hole;
2. Sandblast the section of reinforcing steel and/or threaded rod scheduled to be embedded in the existing concrete to white metal;
3. All holes shall be thoroughly cleaned and prepared in accordance with the epoxy manufacturer's instructions. If compressed air is used, the air shall be filtered to prevent oil or other contamination from entering the hole adversely impacting bonding;
4. Place the epoxy in the drilled hole in accordance with the manufacturer's instructions;
5. Clean the reinforcing bar and/or threaded rod in accordance with the manufacturer's instructions; and
6. Insert the reinforcing bar and/or threaded rod into the drilled hole. In the horizontal drilled holes, caulk the annular space between the entrance of the hole and the bar and/or threaded rod with lead wool or approved equal.

NOTE: For factory coated epoxy bars, item 2 immediately above shall be omitted.

6-02.3(32) REPAIR OF SPALLED AND DELAMINATED CONCRETE

6-02.3(32)A DESCRIPTION

This work shall consist of cleaning and repairing loose, spalled, and delaminated concrete at locations indicated on the Drawings and in accordance with the following subsections.

6-02.3(32)B CLEANING AND PREPARATION

The Contractor shall remove all loose, defective and delaminated concrete by chipping or with high pressure water jets. All cracks and cavities shall be chipped so that their sides are approximately perpendicular to the exposed surface and form a mechanical shoulder at least 1/2-inch in depth. The final depth of concrete removal shall be as indicated in the Contract. In addition to chipping, all concrete to be repaired shall be cleaned of all dirt, grease, oil, moss, scale, rust, and loose particles.

Care shall be taken in removing concrete to prevent overbreakage. Concrete shall be carefully broken away from reinforcing bars where applicable, to prevent damage to steel reinforcement.

6-02.3(32)C REPAIRS

Two proposed methods of repairing concrete are available to the Contractor:

1. Hand placed sand and cement grout with approved epoxy bonding agent; and
2. Quick-set concrete.

Hand placed sand and cement grout shall be used only on the smaller spalled areas with a depth of 1/2-inch or less. All repairs shall be finished to the original size and contour of the member being repaired.

Spall depths over 1-inch shall be reinforced with 4 X 4 WO.5. welded wire fabric secured to the existing concrete with 1/4-inch tie wire anchors and 16 gauge wire ties. Welded wire fabric shall have a minimum 1/2-inch cover, preferably 3/4-inch. Location, spacing and type of anchor shall be sufficient to permanently retain the concrete patch in-place.

6-02.3(33) EPOXY INJECTION OF CONCRETE CRACK

6-02.3(33)A GENERAL

Cracks in existing concrete shall be repaired by epoxy injection where indicated on the Drawings in accordance with the following Specifications.

The Contractor shall submit the epoxy manufacturer's recommended instructions for the step by step total epoxy injection process including but not limited to crack preparation; preliminary surface sealing; entry port insertion and spacing detail; epoxy injection process including how identify "the crack is filled"; sequencing and timing of injections; curing requirements; the epoxy applicator's qualifications including at least 2 recent projects with dates, locations, owner contacts and the contact's telephone number for successful epoxy resin repairs on concrete structures; a Manufacturer's Certificate of Compliance and certified laboratory test reports of the epoxy crack repair results; any necessary requirements related to initial set and obtaining design strength; and any other descriptive information about the complete process to the Engineer for approval at least 10 Working Days prior to performing this work.

The material used as a surface seal shall have adequate strength and adhesion to hold injection ports firmly in place and to resist injection pressures adequately to prevent leakage during injection.

The epoxy resin system for crack injection shall be a Type I, Grade 1 system conforming to ASTM C881 except for the following requirements:

Gel Time[1]	20 Minutes Minimum
Viscosity	700 Centipoise Maximum
Shrinkage	Not Required
Heat Deflection Temperature	130 °F. Minimum

[1]Gel time shall not apply if continuous flow nozzle mixing injection equipment is used.

The injection equipment shall have the Capability of discharging the mixed adhesive at pressures indicated in the manufacturer's application instructions.

6-02.3(33)B GUIDELINES

Epoxy injection repair of concrete cracks over 0.006 inch wide, as designated and marked by the Engineer, shall include as a minimum:

1. Before repair work begins, cracks shall be prepared to accept epoxy in accordance with the epoxy manufacturer's instructions;
2. Entry ports shall be provided, placed, and spaced in the crack in accordance with the epoxy manufacturer's instructions;
3. Unless required otherwise by the epoxy manufacturer's written instructions, prior to injection of the crack, the surface sealing system shall be applied to the face of the crack and areas around entry ports to attain a seal Capable of withstanding the applied injection pressures. For through cracks, the surface seal shall be applied to all accessible faces;
4. Unless required otherwise by the epoxy manufacturer's written instructions, the surface seal shall be allowed to gain adequate strength before proceeding with the injection. However, prior to epoxy injection, the crack should be air injected to determine if the crack is Capable of epoxy injection (air detected coming out of adjacent ports means that the crack can be injected). If the crack is not Capable of being injected, the entry port should be temporarily abandoned and procedure repeated at adjacent ports. At a later time, previously non-injectable cracks should be given a second air injection test;
5. Unless required otherwise by the epoxy manufacturer's written instructions, the injection of the adhesive into each crack shall begin at the entry port at the lowest elevation. Injection of deck cracks shall be done from the top side; through cracks may require sealing the crack on the bottom surface. Injection shall continue at the first port until the injection adhesive begins to flow out of the port at the next higher elevation. The first port shall be plugged and injection started at the second port until adhesive flows from the next port. The entire crack shall be injected with the same sequence. If port to port travel of epoxy adhesive is not indicated, the work shall immediately be stopped and the Engineer notified. On wide cracks where resin travel between ports is expected to be rapid, two or more ports may be pumped simultaneously. On exceptionally large cracks, a formulation (dependent upon crack width, ambient temperature, modulus requirements and other variables) of epoxy resin and fine sands shall be used as recommended by the epoxy manufacturer and approved by the Engineer;
6. After the injection adhesive has cured, the surface seal shall be removed. The face of the crack shall be finished flush with the adjacent concrete. There shall be no indentations or protrusions caused by placement of entry ports;
7. Supervision of this process by the manufacturer’s representative shall be required until the Contractor is familiar with the products and the operations; and
8. The Engineer may evaluate the crack repair by requiring a core or cores of the repaired crack be taken at locations designated by the Engineer and evaluating the cores as specified in the following paragraph.

The Contractor shall obtain three core samples in the first 100 linear feet of crack repaired and one core sample for each 100 linear feet thereafter at no additional cost to the Owner. The core diameter shall be no less than 2 inches. The core length shall be for the full crack depth and taken from locations selected by the Engineer. If less than 90% of the visible crack is filled with epoxy adhesive, the crack from which the cores were taken shall be deemed not to have been repaired in accordance with this Specification and no payment will be made until acceptable repairs are completed by the Contractor. The Contractor shall re-inject the crack, and the repair will again be subject to the approval of the Engineer. Cores determined by the Engineer to be at least 90% filled, shall be trimmed square to a length to diameter ratio of 2 to 1. When tested in compression to failure. If failure does not occur along the repaired crack, the crack repair shall be considered acceptable.

Upon acceptance of the repair by the Engineer, the Contractor shall fill the core holes using an epoxy bonding agent and Portland cement mortar (f'_c = 4,000 psi minimum) and finish the surface smooth with the adjacent concrete.

6-02.3(34) REMOVAL OF CONCRETE / BONDING NEW CONCRETE TO EXISTING CONCRETE

6-02.3(34)A REMOVAL OF CONCRETE - GENERAL

The Contractor shall remove existing concrete as noted, and to the limits indicated, on the Drawings. The Contractor shall submit to the Engineer for review, a demolition plan with working Shop Drawings showing the method of removing portions of the existing concrete structure. The Contractor shall demonstrate to the Engineer that the method and equipment for removing portions of existing concrete are adequate for the intended purpose and provide acceptable results. The removal shall not begin until authorized in writing by the Engineer. Explosives shall not be used in the demolition.

Exposed reinforcing steel shall be cut a minimum of one (1) inch behind the final surface. The void left by removal of the reinforcing steel shall be coated with an approved epoxy resin. Care shall be taken in removing concrete to prevent overbreakage or damage to portions of the existing structure which are to remain. Any damage, due to the Contractor's operations, to the existing structure which is to remain shall be repaired by the Contractor, as approved by the Engineer, at no additional cost to the Owner.

Loose particles, dust, dirt, oil, moss, and other deleterious material shall be removed. The remaining concrete surface shall be acceptable for one or both of the following finishes as indicated in the Contract.

6-02.3(34)A1 CONCRETE REMOVAL WITHOUT REPLACEMENT

The remaining concrete surface shall be patched with grout to a smooth finished surface. The grout shall consist of cement and fine aggregate mixed in the proportions to match the existing work as nearly as practicable. The Contractor shall submit to the Engineer at least 10 Working Days in advance of this work, a grout mixture including admixture if recommended by the grout manufacturer, bonding agent as necessary, and bonding agent manufacturer's final concrete surface preparation indicating the finished surface material provides a strong bond with existing concrete and is durable.

6-02.3(34)A2 BONDING NEW CONCRETE TO EXISTING CONCRETE

Unless the concrete bonding manufacturer's recommended preparation procedure states otherwise, the existing concrete surface shall be prepared as necessary in accordance with the general removal requirements specified above. The concrete surface to which new concrete is to be bonded shall have a rough and jagged texture. Unless indicated otherwise in the Contract, the minimum amplitude of concrete roughening shall be 1/4 inch as defined in ACI "Concrete Repair Basics" Course Manual SCM-24(91). This texture will be measured under a straight board four (4) foot in length where surface peaks to adjacent valleys shall average 1/4 inch depth minimum displacement along the board's length. The Contractor shall make every reasonable effort to obtain valleys not exceeding 1/2 inch maximum from the original surface and peaks not greater than 1/8 inch from the original surface. Each peak shall be jagged. Along the four foot board length, the number of peaks shall be a minimum 30, and the number of valleys shall be a minimum 30. At each test location, the Engineer will place the board in three (3) directions to verify roughness.

Steel reinforcing bars, extending from the existing concrete surface which are to remain as indicated on the Drawings, shall be carefully cleaned of all existing concrete, oil, rust, scale, and other deleterious material. New reinforcing steel shall be spliced to the existing bar unless otherwise specified in the Contract.

The Contractor shall submit to the Engineer at least 10 Working Days in advance of this work, a concrete bonding agent suitable for the conditions anticipated including time to place concrete forms, a surface preparation procedure if different, and a Manufacturer's Certificate of Compliance stating the bonding agent manufacturer's recommended procedure produces an acceptable bond between new concrete and existing concrete.

6-02.3(35) SUPERSTRUCTURE

The superstructure for bridges shall include the following materials (except those noted in the following) above the top of the cross beams or pedestals as the case may be, and between the abutment expansion joints, including concrete Class 4000, reinforcing steel, prestressed concrete girders, deck slab, diaphragms, sidewalks, curb/parapets, earthquake restrainers, railing anchorage, concrete for precast and prestressed components, prestressing steel, expansion joints, inserts, compression seals, elastomeric pads and bridge drains with reducers.

Exceptions: Items excluded under "superstructure" are the following:

1. Metal traffic and pedestrian railings and posts;
2. Steel bridge bearings;
3. Girders;
4. Downspouts;
5. Painting;
6. Light poles (standards) luminaires and other electrical-related items specified elsewhere herein; and
7. Electrical conduit/expansion fittings, junction boxes and condulets.

6-02.3(36) BRIDGE DRAINS

The Contractor shall furnish and install bridge drains of the type specified on Standard Plan no. 290, unless the Contract specifies otherwise. Bridge drains shall be located and installed as shown on the Drawings. Downspout pipe weld connected to bridge drains shall be a minimum inside diameter of 6 inch and all bends shall have a radius not less than 4 feet.

Bridge drains shall be furnished with vaned grates as shown in Standard Plan no. 265. The grate cover shall be fitted to the casting and shall be ground to rest evenly and without rocking on the frame.

When the Contract requires clean outs, they shall be of the size and type specified, and shall be installed as indicated at the specified locations.

Standard weight galvanized steel pipe shall be shop welded to the bridge drain casting. Galvanizing of the pipe shall be in accordance with ASTM A 53, "Black and Hot-Dipped Zinc-Coated Welded and Seamless Steel Pipe for Ordinary Uses". Galvanizing the pipe shall be done after all pipe fabrication including but not limited to cutting to length, grooving, or threading.

After welding, the drain castings and grating covers shall be coated inside and outside with an asphaltic base, black dipping paint. This asphaltic coating shall extend over that portion of the galvanized steel pipe adjacent to the casting far enough to cover the welds.

The Contractor shall submit to the Engineer at least 5 Working Days in advance of this work, a Shop Drawing with product information of the casting, grate, pipe connection, pipe diameter(s) and bend radii as applicable, and asphaltic base black dipping paint. When clean outs are indicated in the Contract, the submittal shall also include information on the clean out(s) such as size, location, installation features, pipe layout, and details of connection to bridge drain or downspout.

See Section 6-02.3(29) regarding downspouts.

6-02.3(37) ELECTRICAL CONDUIT AS-BUILT DRAWINGS

For electrical conduit runs to be confined within concrete Structures such as floor slabs, retaining walls, abutments, or bridge superstructures, the Contractor shall provide as-built drawings of the conduits at least 5 Working Days prior to placing concrete. See Section 8-33.3(2)A.

6-02.4 MEASUREMENT

Bid items of work completed pursuant to the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs herein this Section.

Measurement for "Concrete (Class) (Designation)" will be by the cubic yard in place. Measurements will be to the neat lines of the Structure as shown in the Contract with the exception of concrete in cofferdam seals. No measurement will be made for concrete below the established elevation of the bottom of the footing or seal. No deduction will be made for pile heads, reinforcing steel, structural steel, bolts, weep holes, rustications, chamfers, edgers, bridge drains, joint filler, junction boxes, miscellaneous hardware, and for conduit and drain pipe less than 6 inches diameter.

Concrete, when used in the seals of underwater cofferdams, will be paid for on the basis of the actual volume deposited as determined by the average cross-sectional area of the inside of the cofferdam except that no measurement will be made for the volume so determined which is outside of an area bounded by vertical planes 1 foot outside of the neat lines of the seal. The limiting vertical planes shall be parallel to the location of the neat lines based upon the traverse and longitudinal centerlines of the seal as shown on the Drawings.

Measurement for "Steel Reinforcing Bar, (Grade)" will be by the pound in place as calculated from the Drawings, unless the Contract indicates otherwise. No allowance will be made for spreaders, form blocks, wire clips or other fastenings, which shall be furnished by the Contractor. When splices are made other than those shown on the Drawings, no allowance will be made for the extra steel required. When shear steel is required at construction joints which are not shown on the Drawings, and which are permitted for the Contractor's convenience, no allowance will be made for the additional steel required.

Measurement for "Steel Reinforcing Bar, (Grade), Epoxy Coated" will be by the pound before epoxy coating is applied, as set forth in the paragraph immediately above for uncoated steel reinforcing bars.

Measurement for "Wire Mesh, (Gage), (Mesh Size)" will be by the square yard for the area covered as calculated from the Drawings. No measurement will be made for required overlap of mesh.

Measurement for "Expansion Joint (Type)" or "Compression Seal (Type)" will not be made at or between the abutment expansion joints when there is a Bid item for "Superstructure". Otherwise, measurement for "Expansion Joint (Type)" or "Compression Seal (Type)" will be per linear foot along the outside of the horizontal and vertical faces.

Measurement for "Downspout, Galvanized Steel Pipe, (Diameter)" will be by the linear foot along the center line of the pipe through fittings.

Measurement for "Superstructure" will be by lump sum. Separate measurement will not be made for those material items described in Section 6-02.3(35), or for those additional items identified in the Contract, as these materials are included with the "superstructure".

When a Bid item for "Superstructure" is included on the Bid Form, no measurement will be made for concrete or reinforcing steel placed in the area defined as superstructure.

When the Bid Form includes the Bid item "Superstructure", no separate measurement will be made for "Bridge Drain" that are to be installed within the area defined as superstructure.

Measurement for gravel backfill for drains will be by the cubic yard as Mineral Aggregate (Type).

6-02.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-02 will be made at the Bid item prices Bid only for the Bid items listed or referenced as follows:

1. "**Concrete, (Class), (Designation)**", per cubic yard.

The Bid item price for "Concrete, (Class), (Designation)" shall include all costs for the work required to furnish and install structural concrete in place including falsework, forms, expansion joint material, and construction of weep holes including gravel backfill for drains surrounding the weep holes. The Bid item price for "Concrete (Class) (Use)" shall exclude concrete in the superstructure when "Superstructure" is a separate Bid item.

2. **"Superstructure",** per lump sum.

The Bid item price for "Superstructure" shall include all costs for the work required to furnish and install the superstructure complete not including the excluded items.

All costs for furnishing and placing the date numerals as specified in Section 6-02.3(15) shall be included in the Bid item price for the Bid item "Superstructure".

All costs related to the work for the overhead clearance signs as specified in Section 6-02.3(17)N shall be considered incidental to the Bid item "Superstructure".

All costs in connection with lifting, transporting, and erecting girders including inserts, shims for leveling, grout, field cutting and bending, rebar for drains, welding, blockouts in girders and slabs, and special construction features shall be included in the Bid item price for "Superstructure".

3. "**Steel Reinforcing Bar, (Grade)**", per pound.

4. "**Steel Reinforcing Bar, (Grade), Epoxy Coated**", per pound.

The Bid item prices for "Steel Reinforcing Bar, (Grade)" and for "Steel Reinforcing Bar, (Grade), Epoxy Coated" shall include all costs for the work required to furnish, fabricate, coat, and place the steel reinforcement as specified, and to provide a bar list and bending diagram. The Bid item prices shall also include all costs for any required threading of reinforcing bars. In Structures of reinforced concrete where there are no structural steel Bid items, such minor metal parts as expansion joints, bearing assemblies, and bolts will be paid for at the Bid item prices for reinforcing steel unless the Contract specifies otherwise. When a Bid item for "Superstructure" is included in the Bid Form, all costs for reinforcing steel in the superstructure shall be considered included in the Bid item price for "Superstructure".

All costs related to test weld as required in Section 6-02.3(24)F shall be included in the Bid item price for "Steel Reinforcing Bar, (Grade)" and shall be at no additional or separate cost to the Owner.

5. "**Wire Mesh, (Gage), (Mesh Size)**", per square yard.

The Bid item price for "Wire Mesh, (Gage), (Mesh Size)" shall include all costs required to furnish and place the mesh as specified.

6. "**Expansion Joint (Type)**", per linear foot.

The Bid item price for "Expansion Joint (Type)" shall include all costs for the work required to furnish and install the complete expansion joint system for bridge roadway slabs as specified, including hardware and miter joints. When the project contains a Bid item for "Superstructure", expansion joints within the superstructure shall be considered incidental to the Bid item "Superstructure".

7. "**Compression Seal (Type)**", per linear foot.

The Bid item price for "Compression Seal (Type)" shall include all costs for the work required to furnish and install the compression seal in place. All costs in connection with the compression seals in the deck, sidewalk slabs, concrete overlay, curbs and abutment backwalls, including miter joints, lubricant adhesive, samples and all necessary items to make a complete installation shall be included in the Bid item price for "Compression Seal (Type)". Refer to Section 6-02.4 for measurement clarification.

8. "**Downspout, Galvanized Steel Pipe, (Diameter)**", per linear foot.

The Bid item price for "Downspout, Galvanized Steel Pipe, (Diameter)" shall include all costs for the work required in connection with furnishing and installing the downspouts, including field measuring, galvanizing, and other items necessary to make a complete construction as specified.

9. **"Drill Hole (Size)",** per linear foot.

The Bid item price for "Drill Hole (Size)" shall include all costs for the work required to perform the drilling as specified.

10. "**Repair Spalled and Delaminated Concrete**", per square foot.

The Bid item price for "Repair Spalled and Delaminated Concrete" shall include all costs for the work required to repair spalled and delaminated concrete.

11. "**Epoxy Injection of Concrete Crack**", per linear foot.

The Bid item price for "Epoxy Injection of Concrete Crack" shall include all costs for the work required to perform the epoxy injection repair.

12. "**Bridge Drain**", per each.

The Bid item price for "Bridge Drain" shall include all costs for the work required to furnish and install drain, reducer, and grate to structure complete. All costs in connection with maintaining and cleaning of bridge drains shall be considered incidental to the construction of the bridge drain.

13. **Other payment information**.

All necessary items not specifically listed as a Bid item in the Bid Form, and payment is not otherwise provided, shall be in accordance with Section 1-04.1(2).

Structure excavation, shoring, cribbing, and cofferdams will be paid in accordance with Section 2-09.5.

Gravel backfill for walls and gravel backfill for drains will be paid as Mineral Aggregate, (Type) in accordance with Section 4-01.5.

Structural removals will be paid in accordance with Section 2-02.5.

See Section 1-05.7 regarding any concrete placed that is not in compliance with the Contract.

Concrete that is placed in water for foundation seals, and that upon testing as required by the Engineer reveals void(s) or joint(s), the Contractor shall repair the void(s) or joint(s), or replace the seal at the Contractor's sole expense and at no additional cost to the Owner.

All costs for curing and finishing concrete shall be considered incidental to the various Bid items comprising the Work.

When testing indicates leakage in the expansion joint system(s) on the bridge deck, the Contractor shall make good the system(s) and all costs incurred thereof shall be borne by only the Contractor and at no additional or separate expense to the Owner.

All costs related to the provision for openings as specified in Section 6-02.3(17)L shall be considered incidental to the various Bid items comprising the Contract and shall be at no additional or separate expense to the Owner.

All costs for the Contractor providing labor, materials, and equipment for making the test sample splices as specified in Section 6-02.3(24)G shall be at the Contractor's sole expense and at no additional or separate cost to the Owner. The Owner will test the Contractor made sample splices at no cost to the Contractor.

All costs in connection with the provision and installation of special anchorage reinforcement as specified in Section 6-02.3(26)C shall be borne by the Contractor and shall be at no additional or separate expense to the Owner.

All costs, including any additional Owner's engineering expenses, in connection with controlling the girder deflection as specified in Section 6-02.3(25)L shall be borne solely by the Contractor.

All costs associated with furnishing and installing Date Numerals, where indicated on the Drawings, shall be incidental to the various Bid Items and shall be at no additional or separate expense to the Owner.

All costs in connection with using air-entraining and/or water-reducing admixture(s) in concrete for the bridge decks, traffic barrier, and pedestrian barrier shall be included in the Bid item prices for the various Bid items involved and shall be at no additional or separate cost to the Owner.

All costs in connection with providing holes for vents, for furnishing and installing cell drainage pipes for box girder structures, and furnishing and placing grout and shims under steel shoes shall be included in the Bid item prices for the various Bid items involved and shall be at no additional or separate expense to the Owner.

All costs in connection with replacing Portland cement with pozzolan shall be included in the Bid item price for the various classes of concrete involved and shall be at no additional or separate cost to the Owner. If the concrete is to be paid for other than by class of concrete, all costs involved with replacing Portland cement with pozzolan shall be included in the Bid item price for the applicable Bid item or Bid items of concrete work and shall be at no additional or separate expense to the Owner.

All costs associated with removing concrete and preparing and finishing the concrete surface as specified in Section 6-02.3(34) shall be included in the concrete removal Bid Item in Section 2-02.5 and shall be at no additional or separate expense to the Owner.

All costs associated with preparing a concrete surface for new concrete shall be included in "Concrete (Class) (Use)" and shall be at no additional or separate expense to the Owner.

All costs for placing anchor bolts as specified in Section 6-02.3(18) shall be incidental to the applicable Bid items unless the Contract specifies otherwise. All costs in connection with furnishing cylinder molds, fabrication, curing, and testing of early concrete test cylinders per Section 6-02.3(17)P shall be included in the Bid item prices for the various Bid items of Work involved and shall be at no additional or separate expense to the Owner.

All costs associated with tension testing and evaluating test data per Section 6-02.3(26)F shall be included in the Bid item prices for the applicable Bid items of Work involved and shall be at no additional or separate cost to the Owner.

In Section 6-02.3(35), the superstructure contains the approximate quantities of materials as listed in the Contract. The quantities listed are for major items only and are not intended to be a complete list of all items required for construction of the superstructure. The quantities are approximate and are for the convenience of the Contractor in determining the volume of work involved and are not guaranteed to be accurate. The prospective Bidders shall verify these quantities before submitting a Bid. No adjustments other than for approved changes will be made in the Bid item lump sum price for "Superstructure" even though the actual quantities required may deviate from those listed.

All cost for Contractor requested changes in concrete accepted by the Engineer as specified in Section 6-02.3(1) shall be at the sole expense of the Contractor and no separate or additional payment will be made therefore.

SECTION 6-03 STEEL STRUCTURES

6-03.1 DESCRIPTION

Section 6-03 addresses the work of furnishing, fabricating, erecting, cleaning, and painting steel structures and the structural steel parts of nonsteel Structures.

Any part of a steel Structure made of nonsteel Materials shall comply with the Sections of the Standard Specifications governing those Materials.

6-03.2 MATERIALS

Materials shall meet the requirements of the following Sections:

Structural Steel and Related Materials	9-06
Paints	9-08

Structural steel shall be classified as:

1. Structural carbon steel (to be used whenever the Contract does not specify another classification);
2. Structural low alloy steel; and
3. Structural high strength steel.

Unless the Contract states otherwise, the following shall be classified as structural carbon steel: shims; ladders; stairways; anchor bolts and sleeves; pipe, fittings and fastenings used in handrails; and other metal parts, even if made of other materials, for which payment is not specified.

All AASHTO M 270 material used in what the Drawings show as main load-carrying tension members or as tension components of flexural members shall meet the Charpy V-notch requirements of AASHTO M 270, temperature zone 2. All

AASHTO M 270 material used in what the Drawings show as fracture critical members shall meet the Charpy V-notch requirements of AASHTO M 270, Fracture Critical Impact Test requirements, temperature zone 2. Charpy V-notch requirements for other steel materials shall be as specified in the Contract. Filler metals for welding shall meet the toughness requirements of the applicable welding code specified in Section 6-03.3(25).

The Contractor shall submit for the Engineer's approval a written plan for visibly marking the material so that it can be traced. These marks shall remain visible at least through the fit-up of the main load-carrying tension members. The marking method shall include the following information:

(1) material specification designation,
(2) heat number, and
(3) material test reports to meet any special requirements.

As-built drawings: for steel in main load-carrying tension members and in tension components of flexural members, the Contractor shall include the heat numbers on the reproducible copies of the as-built Shop Drawings (see Section 1-05.3(11)).

6-03.3 CONSTRUCTION REQUIREMENTS

Structural steel fabricators of girders, floorbeams, truss members, and stringers, for permanent steel bridges, shall be certified under the AISC Quality Certification Program, Category III, Major Steel Bridges. When fracture critical members are specified in the Contract, structural steel fabricators shall also have an endorsement F, Fracture Critical, under the AISC Quality Certification Program.

6-03.3(1) NOTICE OF ROLLING

Before rolling work begins, the Contractor shall provide enough advance notice that the Engineer may arrange to observe it. The Contractor shall inform the Engineer of who is to do the work and where it is to be done. No material shall be rolled until the Engineer gives written notice to Proceed.

6-03.3(2) FACILITIES FOR INSPECTION

See Sections 1-05.6 and 1-06 for the Engineer's right to inspect Material and workmanship.

6-03.3(3) INSPECTOR'S AUTHORITY

See Section 1-05.

6-03.3(4) REJECTIONS

See Sections 1-05 and 1-06.

6-03.3(5) MILL ORDERS AND SHIPPING STATEMENTS

The Contractor shall furnish as many copies of mill orders and shipping statements as the Engineer requires.

6-03.3(6) WEIGHING

Structural steel need not be weighed unless specified otherwise in the Contract. When weight is specified, it may either be calculated or obtained by scales. The Contractor shall furnish 4 copies of the calculations or weight slips unless the Contract specifies another quantity. If scale weights are used, the Contractor shall record separately the weights of all tools, erection material, and dunnage.

6-03.3(7) SUBMITTALS

6-03.3(7)A SHOP DRAWINGS AND AS-BUILT RECORDS

The Contractor shall submit to the Engineer for review all Shop Drawings, and certified mill test reports, for fabricating the steel. Prints of the Shop Drawings shall be supplied in these quantities:

Ten sets to the Engineer (four more sets are required for each affected railroad company on any grade separation structure that carries a railroad over a highway).

The Engineer will return the Shop Drawings to the Contractor. When Shop Drawing sheets returned by the Engineer require correction, the Contractor shall correct and resubmit them in the quantities required above. No material shall be fabricated until:

(1) the Engineer has reviewed all Shop Drawings; and
(2) the SPU Materials Laboratory has approved the Material source(s) and the fabricator(s).

See Section 1-05.3 regarding Shop Drawings.

As-built records: Before the Physical Completion Date can be established, the Contractor shall furnish the Engineer one set of reproducible copies of the as-built Shop Drawings (see Sections 1-05.3(11) and 1-05.3(13)). An additional set of as-built Shop Drawings is required for each affected railroad company on any grade separation Structure that carries a railroad over a transportation Right of Way. The reproducible as-built Shop Drawings shall be 22 inches by 34 inches and shall meet the requirements of Section 1-05.3(10).

6-03.3(7)B ERECTION METHODS

The Contractor shall submit a steel erection plan and procedure describing the methods the Contractor intends to use to the Engineer for review. The Contractor shall have received the Engineer's returned submittal for the erection plan and procedure before doing this work. The Contractor's erection plan and procedure shall first be reviewed by the steel fabricator prior to being submitted to the Engineer. The Contractor's submittal shall include evidence that the fabricator has reviewed the erection Shop Drawings and procedures; and shall submit the fabricator's review comments with the erection plan submittal.

The erection plan and procedure shall provide complete details of the erection process including but not limited to:

1. Temporary falsework support, bracing, guys, deadmen, and attachments to other structure components or objects;
2. Procedure and sequence of operation;
3. Girder stresses during progressive stages of erection;
4. Girder masses, lift points, and lifting devices, spreaders, glommers, etc.;
5. Crane(s) make and model, masses, geometry, lift capacity, outrigger size and reactions;
6. Girder launcher or trolley details and capacity (if intended for use); and
7. Locations of cranes, barges, trucks delivering girders, and the location of cranes and outriggers relative to other structures, including retaining walls and wing walls.

The erection plan shall include Shop Drawings, notes, catalog cuts, calculations clearly showing the above listed details, assumptions, and dimensions, material properties, specifications, structural analysis, and any other necessary data. The erection plan shall be prepared by a professional engineer in accordance with Section 1-05.3(12).

The Contractor shall submit the erection Shop Drawings, calculations, procedure, and fabricator's comments directly to the Engineer, in accordance with Section 6-02.3(16). After the plan is reviewed and returned to the Contractor, any change that the Contractor proposes to the reviewed submittal shall be in accordance with Section 1-05.3(5).

6-03.3(8) SUBSTITUTIONS

The Contractor shall not substitute sections that differ from Drawings or Engineer reviewed Shop Drawings dimensions unless the Contractor has submitted the substitution for review by the Engineer. If the Contractor's submittal requests substitution of heavier members which exceed Contract requirements, such substitution shall be at no additional cost to the Owner. Also see the requirements of Sections 1-05.3(5).

6-03.3(9) HANDLING, STORING, AND SHIPPING OF MATERIALS

Markings applied at the mill shall distinguish structural low alloy steel from structural carbon steel. The fabricator shall keep the two classes of steel carefully separated.

Before fabrication, all material stored at the fabricating plant shall be protected from rust, dirt, oil, and other foreign matter. The Owner will not accept rust-pitted material.

After fabrication, all material awaiting shipment shall be subject to the same storage requirements as unfabricated material.

All structural steel shall arrive at the Project Site in a condition meeting or exceeding the specified requirements. Steel damaged by salt water shipment shall be thoroughly cleaned by high pressure water flushing, chemical cleaning, or sandblasting, and repainted with the specified shop coat in compliance with specified requirements.

All material shall be stored to prevent rust and loss of small parts. Piled material shall rest on skids or platforms, and shall not make contact with the ground or with water.

The loading, transporting, unloading, and stockpiling of the structural steel material shall be so conducted that the metal is kept clean and free from injury from rough handling.

In field assembly of structural parts, the Contractor shall use methods and equipment that shall not twist, bend, deform, or otherwise injure the metal. Any bent or twisted member shall be corrected before it is placed. The Owner will not accept any member with damage.

Girder sections shall be handled to prevent damage to the girders. The Contractor shall provide temporary stiffeners to prevent buckling during erection as necessary.

6-03.3(10) CORRECTING BENT MATERIAL

Plates, angles, other shapes, and built-up members may be straightened if authorized in writing by the Engineer. Straightening methods shall not fracture or injure the metal. Distorted members shall be straightened mechanically. A limited amount of localized heat may be applied only if carefully planned and supervised, and only if the Engineer has approved a heat-straightening procedure in writing.

Parts to be heat-straightened shall be free from all stress and external forces except those that result from the mechanical pressure used with the heat.

After straightening, the Contractor shall inspect the member for fractures using a method specified in the Contract.

The Engineer will reject metal showing sharp kinks and bends.

The procedure for heat straightening of universal mill (UM) plates by the mill or the fabricator shall be submitted to the Engineer for review prior to doing this work.

6-03.3(11) WORKMANSHIP AND FINISH

Workmanship and finish shall be first-class, equaling the best practice in modern bridge fabrication shops. Welding, shearing, burning, chipping, and grinding shall be done neatly and accurately. All parts of the work exposed to view shall be neatly finished.

Wherever the Drawings show a surface finish symbol, the surface shall be machined.

6-03.3(12) FALSEWORK

All falsework shall conform to the requirements specified in Section 6-02.

6-03.3(13) FABRICATING TENSION MEMBERS

Plates for main load-carrying tension members or tension components of flexural members shall be:

1. Blast cleaned entirely or blast cleaned on all areas within 2 inches of welds to SSPC-SP6, Commercial Blast Cleaning; and
2. Fabricated from plate stock with the primary rolling direction of the stock parallel to the length of the member.

6-03.3(14) EDGE FINISHING

All rolled, sheared, and flame-cut edges shall be true to line and free of rough corners and projections. Corners along exposed edges shall be rounded to a minimum radius of 1/16-inch.

Sheared edges on plates more than 5/8 inch thick shall be planed, milled, ground, or flame-cut to a depth of at least 1/8 inch.

Re-entrant corners or cuts shall be filleted to a minimum radius of 3/4 inch.

Exposed edges of main load-carrying tension members or tension components of flexural members shall have a surface roughness no greater than 250 micro-inches as defined by the American National Standards Institute, ANSI B46.1, Surface Texture. Exposed edges of other members shall have surface roughness no greater than 1,000 micro-inches.

The hardness of flame-cut edges of structural low alloy plates, as specified in Section 9-06.2, for main load-carrying tension members or tension components of flexural members shall meet the requirements outlined in Appendix A, “Testing Rockwell Hardness of Flame-cut Edges” to be found in the appendix of the Project Manual. The Contractor shall prevent excessive hardening of plate edges through preheating, postheating, or control of the burning process as recommended by the steel manufacturer and approved by the Engineer.

6-03.3(15) PLANING OF BEARING SURFACES

Ends of columns that bear on base and cap plates shall be milled to true surfaces and accurate bevels.

When assembled, caps and base plates of columns and the sole plates of girders and trusses shall have full contact. If warped or deformed, the plates shall be heat straightened, planed, or corrected in some other way to produce accurate, even contact. If necessary for proper contact, bearing surfaces that are to be in contact with other metal surfaces shall be planed or milled. Surfaces of warped or deformed base and sole plates that are to in contact with masonry shall be rough finished.

On the surface of expansion bearings, the cut of the planer shall be in the direction of expansion.

6-03.3(16) ABUTTING JOINTS

Abutting ends of compression members shall be faced accurately so that they bear evenly when in the Structure. On built-up members, the ends shall be faced or milled after fabrication.

Ends of tension members at splices shall be rough finished to produce neat, close joints. A contact fit is not required.

6-03.3(17) END CONNECTION ANGLES

On floorbeams and stringers, end connection angles shall be flush with each other and set accurately in relationship to the position and length of the member. End connection angles shall not be finished unless specified otherwise in the Contract. If, however, faulty assembly requires them to be milled, milling shall not reduce thickness by more than 1/16 inch.

6-03.3(18) BUILT-UP MEMBERS

The various pieces forming one built-up member shall be straight and close-fitting, true to detailed dimensions, and free from twists, bends, open joints, or other defects.

When fabricating curved girders, localized heat or the use of mechanical force shall not be used to bend the girder flanges about an axis parallel to the girder webs.

6-03.3(19) HAND HOLES

Hand holes, whether punched or cut with burning torches, shall be true to sizes and shapes shown on the Drawings. Edges shall be true to line and ground smooth.

6-03.3(20) LACING BARS

Unless the Contract states otherwise, ends of lacing bars shall be neatly rounded.

6-03.3(21) PLATE GIRDERS

6-03.3(21)A WEB PLATES

If web plates are spliced, clearance between plate ends shall not exceed 3/8 inch.

6-03.3(21)B RESERVED

6-03.3(21)C WEB SPLICES AND FILLERS

Web splice plates and fillers under stiffeners shall fit within 1/8 inch at each end.

6-03.3(22) EYEBARS

Eyebars shall be straight, true to size, and free from twists or folds in the neck or head and from any other defect that would reduce their strength. Heads shall be formed by upsetting, rolling, or forging. Dies in use by the manufacturer may determine the shape of bar heads if approved in writing by the Engineer. Head and neck thickness shall not overrun by more than 1/16 inch. Welds shall not be made in the body or head of any bar.

Each eyebar shall be properly annealed and carefully straightened before it is bored. Pinholes shall be located on the centerline of each bar and in the center of its head. Holes in bar ends shall be so precisely located that in a pile of bars for the same truss panel, the pins may be inserted completely without driving. All eyebars made for the same locations in trusses shall be interchangeable.

6-03.3(23) ANNEALING

All eyebars shall be annealed by being heated uniformly to the proper temperature, then cooled slowly and evenly in the furnace. At all stages, the temperature of the bars shall be under full control.

Slight bends on secondary steel members may be made without heat. Crimped web stiffeners need no annealing.

6-03.3(24) PINS AND ROLLERS

6-03.3(24)A GENERAL

Pins and rollers shall be made of the class of forged steel as specified on the Drawings. They shall be turned accurately to detailed dimensions, smooth, straight, and flawless. The final surface shall be produced by a finishing cut.

Pins and rollers 9 inches or less in diameter may either be forged and annealed, or made of cold-finished carbon steel shafting.

Pins more than 9 inches in diameter shall have holes at least 2 inches in diameter bored longitudinally through their centers. Pins with inner defects will be rejected.

The Contractor shall provide pilot and driving nuts for each size of pin unless the Contract specifies otherwise.

6-03.3(24)B BORING PIN HOLES

Pin holes shall be bored true to detailed dimensions, smooth and straight, and at right angles to the axis of the member. Holes shall be parallel with each other unless the Contract specifies otherwise. A finishing cut shall always be made.

The distance between holes shall not vary from detailed dimensions by more than 1/32 inch. In tension members, this distance shall be measured from outside to outside of holes. In compression members, this distance shall be measured from inside to inside of holes.

6-03.3(24)C PIN CLEARANCES

Each pin shall be 1/50-inch smaller in diameter than its hole. All pins shall be numbered after being fitted into their holes in the assembled member.

6-03.3(25) WELDING AND REPAIR WELDING

6-03.3(25)A GENERAL

Welding and repair welding of all steel bridges shall comply with the ANSI / AASHTO / AWS D1.5-96, Bridge Welding Code. Welding and repair welding for all other steel fabrication shall comply with AWS D1.1, latest edition, Structural Welding Code. The requirements described in the remainder of this Section shall prevail whenever they differ from either of the above welding codes.

Welding of structural steel will be permitted only to the extent shown on the Drawings. No welding, including tack and temporary welds, shall be done in the shop or field unless the location of the welds is shown on the submitted Shop Drawings reviewed by the Engineer.

Welding procedures shall be submitted with the Shop Drawings. The procedures shall specify the type of equipment to be used, electrode selection, preheat requirements, base materials, and joint details. When the procedures are not prequalified by AWS or AASHTO, evidence of qualification tests indicating the approval of a recognized agency shall be included in the submittal.

Welding shall not begin until after the Contractor has received the Engineer's review of Shop Drawings as required in Section 6-03.3(7). These Shop Drawings shall include procedures for welding, assembly, and any heat-straightening or heat-curving.

Any welded shear connector longer than 8 inches may be made of two shorter shear connectors joined with full-penetration welds.

In shielded metal-arc welding, the Contractor shall use low-hydrogen electrodes.

In submerged-arc welding, flux shall be oven-dried at 550°F for at least 2 hours, then stored in ovens held at 250°F or more. If not used within 4 hours after removal from a drying or storage oven, flux shall be redried before use.

Preheat and interpass temperatures shall conform to the applicable welding code as specified in this Section. When welding main members of steel bridges, the minimum preheat shall not be less than 100°F.

If groove welds (web-to-web or flange-to-flange) have been rejected, they may be repaired no more than twice. If a third failure occurs, the Contractor shall at the Engineer's discretion:

1. Trim the members, if the Engineer approves, at least 1/2 inch on each side of the weld; or
2. Replace the members at no additional cost to the Owner.

By using extension bars and runoff plates, the Contractor shall terminate groove welds in a way that ensures the soundness of each weld to its ends. The bars and plates shall be removed after the weld is finished and cooled. The weld ends shall then be ground smooth and flush with the edges of abutting parts.

The Contractor shall not:

a. Weld with electrogas or electroslag methods;
b. Weld nor flame cut when ambient temperature is below 20°F; or
c. Use coped holes in the web for welding butt splices in the flanges unless the Drawings show them.

6-03.3(25)B WELDING INSPECTION

The Contractor's inspection procedures, techniques, methods, acceptance criteria and inspector qualifications for welding of steel bridges shall be in accordance with the ANSI / AASHTO / AWS D1.5-96, Bridge Welding Code. The Contractor's inspection procedures, techniques, methods, acceptance criteria and inspector qualifications for welding of all steel Structures other than steel bridges shall be per AWS D1.1, latest edition, Structural Welding Code. The requirements described in the remainder of this section shall prevail whenever they differ from either of the above welding codes.

Nondestructive testing, in addition to visual inspection, shall be performed by the Contractor. Unless otherwise specified in the Contract, the extent of inspection shall be as specified in this Section. Testing and inspection shall apply to welding performed in the shop and in the field.

1. **Visual Inspection**
   All welds shall be 100 percent visually inspected. Visual inspection shall be performed before, during, and after the completion of welding.
2. **Radiographic Inspection**
   Complete penetration tension groove welds in highway bridges shall be 100 percent radiographically inspected. These welds include those in the tension area of webs where inspection shall cover the greater of these two distances:

   a. 15 inches from the tension flange or
   b. one third of the web depth.

   In addition, edge blocks conforming to the requirements of AWS D1.1-96 Structural Welding Code Section 6.17.13 shall be used for radiographic inspection.
3. **Ultrasonic Inspection**
   Complete penetration groove welds on plates thicker than 5/16 inch in the following welded assemblies or structures shall be 100 percent ultrasonically inspected:
   a. Welded connections and splices in highway bridges and earth retaining Structures, excluding longitudinal butt welds in beam or girder webs;
   b. Bridge bearings and modular expansion joints;
   c. Sign bridges, cantilever sign Structures, and bridge mounted sign brackets excluding longitudinal butt joint welds in beams;
   d. Light, signal, and strain pole standards; and
   e. Steel Casing for concrete columns.
   The testing procedure and acceptance criteria for tubular members shall conform with Section 10 of the latest edition of the AWS Structural Welding Code D1.1 - Steel.
4. **Magnetic Particle Inspection**
   a. Fillet and partial penetration groove welds: At least 30 percent of each size and type of fillet welds (excluding intermittent fillet welds) and partial penetration groove welds in the following welded assemblies or Structures shall be tested by the magnetic particle method:
      (1) Flange-to-web connections in highway bridges;
      (2) End and intermediate pier diaphragms in highway bridges;
      (3) Stiffeners and connection plates in highway bridges;
      (4) Welded connections and splices in earth retaining Structures;
      (5) Boxed members of trusses;
      (6) Bridge bearings and modular expansion joints;
      (7) Sign bridges, cantilever sign Structures, and bridge mounted sign brackets; and
      (8) Light, signal, and strain pole standards.
   b. Longitudinal butt welds in beam and girder webs: At least 30 percent of each longitudinal butt weld in the beam and girder webs shall be tested by the magnetic particle method.
   c. Complete penetration groove welds on plates 5/16 inch or thinner shall be 100 percent tested by the magnetic particle method. Testing shall apply to both sides of the weld, if backing plate is not used.
   d. The ends of each complete penetration groove weld at plate edges shall be tested by the magnetic particle method.

The Contractor shall have all welds of structural members inspected by 100% radiographic or ultrasonic inspection, or by a combination of both, in accordance with the applicable specification in 2. and 3. above and in compliance with the last paragraph of this section.

Where 100 percent testing is not required, the Engineer reserves the right to select the location(s) for testing.

If rejectable flaws are found in any test length of weld in item 4. Magnetic Particle Inspection, subitems (a) or (b) in this Section, the full length of the weld or 5 feet on each side of the test length, whichever is less, shall be tested.

After repairs of defects have been made, additional nondestructive testing shall be performed to ensure that the repairs are acceptable. This testing shall include the repaired area plus at least 2 inches on each side of the repaired area.

After the Contractor has completed his welding inspection, the Contractor shall allow the Engineer sufficient time to perform quality assurance ultrasonic welding inspection.

The Contractor shall maintain the video records of ultrasonic inspections and the ultrasonic inspection reports in the shop until the last joint to be tested by ultrasonic means has been accepted by the inspector conducting these inspections for the Contractor. Within 2 Working Days following this acceptance, the Contractor shall mail the film and video record together with 2 copies each of the radiographic and ultrasonic inspection reports to the Engineer.

6-03.3(26) SCREW THREADS

Screw threads shall be U.S. Standard and shall fit closely in the nuts.

6-03.3(27) HIGH STRENGTH BOLT HOLES

6-03.3(27)A GENERAL

At the Contractor's option under the conditions described in this Section, holes may be punched or subpunched and reamed, drilled or subdrilled and reamed, or formed by numerically controlled drilling operations.

The hole for each high strength bolt shall be 1/16-inch larger than the nominal diameter of the bolt.

In fabricating any connection, the Contractor may subdrill or subpunch the holes and then ream full size after assembly or drill holes full size from the solid with all thicknesses of material shop assembled in the proper position. If the Contractor chooses not to use either of these methods, the following shall apply:

1. Drill bolt holes in steel splice plates full size using steel templates;
2. Drill bolt holes in the main members of trusses, arches, continuous beam spans, bents, towers, plate girders, box girders, and rigid frames at all connections as follows:
    a. A minimum of 30 percent of the holes in one side of the connection shall be made full size using steel templates;
    b. A minimum of 30 percent of the holes in the second side shall be made full size assembled in the shop; and
    c. All remaining holes may be made full size in unassembled members using steel templates; and
3. Drill bolt holes in crossframes, gussets, lateral braces, and other secondary members full size using steel templates.

The Contractor shall submit for the Engineer's review, a detailed outline of the procedures proposed to accomplish the work from initial drilling through shop assembly.

6-03.3(27)B PUNCHED HOLES

For punched holes, die diameter shall not exceed punch diameter by more than 1/16 inch. Any hole requiring enlargement to admit the bolt shall be reamed. All holes shall be cut clean with no torn or ragged edges. The Owner will reject components having poorly matched holes.

6-03.3(27)C REAMED AND DRILLED HOLES

Reaming and drilling shall be done with twist drills, or with short taper reamers, producing cylindrical holes perpendicular to the member. Reamers and drills shall be directed mechanically, not hand-held. Connecting parts that require reamed or drilled holes shall be assembled and held securely as the holes are formed, then match-marked before disassembly. The Contractor shall provide the Engineer with a diagram showing these match-marks. The Owner will reject components having poorly matched holes.

Burrs on outside surfaces shall be removed. The Contractor shall disassemble parts to remove burrs as applicable.

If templates are used to ream or drill full-size connection holes, the templates shall be positioned and angled with accuracy and bolted securely in place. Templates for reaming or drilling matching members, or the opposite face of one member, shall be duplicates. All splice components shall be match-marked.

6-03.3(27)D NUMERICALLY CONTROLLED (N/C) DRILLED CONNECTIONS

In forming any hole described in Section 6-03.3(27), the fabricator may use numerically controlled (N/C) drilling or punching equipment if it meets the requirements in this Section.

The Contractor shall submit for review, a detailed outline of proposed N/C procedures. This outline shall:

1. Cover all steps from initial drilling or punching through check assembly; and
2. Include the specific members of the Structure to be drilled or punched, hole sizes, locations of the common index and other reference points, makeup of check assemblies, and all other information needed to describe the process fully.

N/C holes may be drilled or punched to size through individual pieces, or may be drilled through any combination of pieces restrained from moving while being drilled.

At the Engineer's request, the Contractor shall demonstrate that the N/C procedures consistently produces holes and connections meeting the requirements of these Specifications.

6-03.3(27)E ACCURACY OF PUNCHED, SUBPUNCHED AND SUBDRILLED HOLES

After shop assembly and before reaming, all punched, subpunched, and subdrilled holes shall meet the following standard of accuracy. At least 75 percent of the holes in each connection shall permit the passage of a cylindrical pin 1/8-inch smaller in diameter than nominal hole size. This pin shall pass through at right angles to the face of the member without drifting. All holes shall permit passage of a pin 3/16-inch smaller in diameter than nominal hole size. The Owner will reject any pieces that fail to meet these standards.

6-03.3(27)F ACCURACY OF REAMED AND DRILLED HOLES

At least 85 percent of all holes in a connection of reamed or drilled holes shall show no offset greater than 1/32-inch between adjacent thicknesses of metal. No hole shall have an offset greater than 1/16-inch.

Centerlines from the connection shall be inscribed on the template, and holes shall be located from these centerlines. Centerlines shall also be used for accurately locating the template relative to the milled or scribed ends of the members.

Templates shall have a hardened steel bushing inserted into each hole. These bushings may be omitted, however, if the fabricator can acceptably demonstrate this to the Engineer:

(1) that the template is to be used no more than 5 times, and
(2) that use produces no template wear.

Each template shall be at least 1/2-inch thick. If necessary, thicker templates shall be used to prevent buckling and misalignment as the holes are formed.

6-03.3(27)G FITTING FOR BOLTING

Before drilling, reaming, and bolting begins, all parts of a member shall be assembled, well pinned, and drawn firmly together. If necessary, assembled pieces shall be taken apart to permit removal of any burrs or shavings produced as the holes are formed. The member shall be free from twists, bends, and other deformation.

In shop-bolted connections, contacting metal surfaces shall be sandblasted clean before assembly. Sandblasting shall meet the requirements of the SSPC Specifications for Commercial Blast Cleaning (SSPC-SP 6).

Any drifting done during assembly shall be no more than enough to bring the parts into place. Drifting shall not enlarge the holes or distort the metal.

6-03.3(28) SHOP ASSEMBLY

6-03.3(28)A METHOD OF SHOP ASSEMBLY

Unless the Contract specifies otherwise, the Contractor shall choose from the following 5 described shop assembly methods, the method that best fits the proposed erection method. The Contractor shall submit and obtain review from the Engineer, both the shop assembly and the erection methods before this work begins.

1. **Full Truss or Girder Assembly**: Each truss or girder is completely assembled over the full length of the superstructure.
2. **Progressive Truss or Girder Assembly**: Each truss or girder is assembled in stages longitudinally over the full length of the superstructure.
    a. **For trusses**: The first stage shall include at least three adjacent truss panels. Each truss panel shall include all of the truss members in the space bounded by the top and bottom chords and the horizontal distance between adjacent bottom chord joints.
    b. **For girders**: The first stage shall include at least three adjacent girder shop sections. Shop sections are measured from the end of the girder to the first field splice or from field splice to field splice.
    c. **For trusses and girders**: After the first stage has been completed, each subsequent stage shall be assembled to include: two truss panels or girder shop sections of the previous stage and one or more truss panels or girder shop sections added at the advancing end. The previous stages shall be repositioned if necessary, and pinned to ensure accurate alignment.

        For girders on tangents without skews or tapers, the Contractor may assemble subsequent stages which include one girder shop section of the previous stage and two or more girder shop sections at the advancing end.

        If the bridge is longer than 150 feet, each longitudinal stage shall be at least 150 feet long, regardless of the length of individual continuous truss panels or girder shop sections.

        The Contractor may begin the assembly sequence at any point on the bridge and proceed in either or both directions from that point.

        No assembly shall have less than three truss panels or girder shop sections.
3. **Full Chord Assembly**: The full length of each chord for each truss is assembled with geometric angles at the joints. Chord connection bolt holes are drilled/reamed while members are assembled. The truss web member connections are drilled/reamed to steel templates set by relating geometric angles to the chord lines.

    At least one end of each web member shall be milled or scribed at right angles to its long axis. The templates at both ends of the member shall be positioned accurately from the milled end or scribed line.
4. **Progressive Chord Assembly**: Adjacent chord sections are assembled in the same way as specified for Full Chord Assembly, using the procedure specified for Progressive Truss or Girder Assembly.
5. **Special Complete Structure Assembly**: All structural steel members (superstructure and substructure, including all secondary members) are assembled at one time.

6-03.3(28)B CHECK OF SHOP ASSEMBLY

The Contractor shall check each assembly for alignment, accuracy of holes, fit of milled joints, and other assembly techniques. Drilling or reaming shall not begin until the Engineer has given written approval. If the Contractor uses N/C drilling, this written approval from the Engineer shall be obtained before the assembly or stage is dismantled.

6-03.3(29) SANDBLASTING

After fabrication, the Contractor shall sandblast all structural steel (except machine-finished surfaces) in accordance with the SSPC-SP10 specification for near-white blast cleaning. After sandblasting and before painting, the Contractor shall remove all loose dust and dirt that remains on the steel. Acid shall not be used to remove scale or stains in the field.

6-03.3(30) SHOP PAINTING

6-03.3(30)A GENERAL

Within 8 hours after the sandblasting required in Section 6-03.3(29), all structural steel shall be painted with one shop coat as the Drawings specify. The Contractor shall not add more volatile thinner to the paint than the formula permits.

The Contractor shall not load structural steel for shipment until the shop coat of paint has dried thoroughly. No painting shall be done after the steel has been loaded for shipment.

Contact surfaces of field bolted connections shall be:

1. Painted with the shop coat when the structure is to be coated with inorganic zinc silicate paint; or
2. Painted with one shop coat of vinyl pretreatment, Formula No. A-5-61, when the structure is to be coated with a paint other than inorganic zinc silicate.

If the contact surfaces of a bolted connection coated with inorganic zinc silicate paint has been kept free from dirt, oil, grease, and other foreign matter, it may be field bolted without further preparation. If it is contaminated, the surface shall be sandblasted no more than 8 hours before final bolting.

All contact surfaces of bolted connections coated with other than inorganic zinc silicate paint shall be cleaned by sandblasting just before final field bolting.

Any sandblasting done before final field bolting shall comply with SSPC Specifications for Commercial Blast Cleaning (SSPC-SP6).

6-03.3(30)B WEATHER CONDITIONS

The Contractor shall submit to the Engineer, the paint manufacturer's recommendations for paint application before application of the paint.

Unless the paint manufacturer recommends otherwise, the Contractor shall apply paint only when air and metal are 40°F or warmer. Major painting on a Structure shall not begin unless the weather is forecast to remain above 40°F for at least 48 hours after painting starts. Minor painting of spots and small areas may be done any time the air and metal meet temperature requirements.

In open yards or on erected structures, the metal shall not be painted while hot enough to blister the paint.

Paint shall never be applied on damp metal. Any metal painted under cover in damp or cold weather shall remain covered until dry or until weather conditions permit open exposure.

6-03.3(30)C APPLICATION

All paint shall be brushed on, unless the Contract specifies another method. Painting shall be done in a professional manner by competent painters. The paint film shall meet the minimum thickness requirements stated in Section 6-07.3(5).

6-03.3(30)D ERECTION MARKS

Erection marks to permit identification of members in the field shall be painted on previously painted surfaces.

6-03.3(30)E MACHINE-FINISHED SURFACES

As soon as possible and before they leave the shop, machine-finished surfaces on abutting chord splices, column splices, and column bases shall be covered with grease. After erection, the steel shall be cleaned and painted as specified.

All surfaces of iron and steel castings milled to smooth the surface shall be painted with the primer called for in the specified paint system.

While still in the shop, machine-finished surfaces and inaccessible surfaces of rocker or pin-type bearings shall receive the full paint system. Surfaces of pins and holes machine-finished to specific tolerances shall not be painted. However, as soon as possible and before they leave the shop, they shall be coated with grease.

6-03.3(31) ALIGNMENT AND CAMBER

6-03.3(31)A GENERAL

Before beginning field bolting, the Contractor shall:

1. Adjust the structure to correct grade and alignment;
2. Regulate elevations of panel points (ends of floorbeams); and
3. Delay bolting at compression joints until adjusting the blocking to provide full and even bearing over the whole joint.

On truss spans, a slight excess camber will be permitted as the bottom chords are bolted. But camber and relative elevations of panel points shall be correct before the top chord joints, top lateral system, and sway braces are bolted.

6-03.3(31)B MEASURING CAMBER

The Contractor shall provide the Engineer with a diagram for each truss that shows camber at each panel point. This diagram shall display actual measurements taken as the truss is being assembled.

6-03.3(32) ASSEMBLING AND BOLTING

To begin bolting any field connection or splice, the Contractor shall install and tighten to snug-tight enough bolts to bring all parts into full contact with each other prior to tightening the bolts to the specified minimum tension.

"Snug-tight" means either the tightness reached by:

(1) a few blows from an impact wrench, or
(2) the full effort of a person using a spud wrench.

As erection proceeds, all field connections and splices for each member shall be securely drift-pinned and bolted in accordance with 1 or 2 following, before the weight of the member can be released or the next member is added. Field erection Shop Drawings shall specify pinning and bolting requirements that meet or exceed the following minimums:

1. **Joints in Normal Structures**: Fifty percent of the holes in a single field connection and 50 percent of the holes on each side of a single joint in a splice plate shall be filled with drift pins and bolts. 30 percent of the filled holes shall be pinned. 70 percent of the filled holes shall be bolted and tightened to snug-tight. Once all these bolts are snug-tight, each bolt shall be systematically tightened to the specified minimum tension. "Systematically tightened" means beginning with bolts in the most rigid part, which is usually the center of the joint, and working out to its free edges. The fully tensioned bolts shall be located near the middle of a single field connection or a single splice plate.
2. **Joints in Cantilevered Structures**: 75 percent of the holes in a single field connection and 75 percent of the holes on each side of a single joint in a splice plate shall be filled with drift pins and bolts. 50 percent of the filled holes shall be pinned. 50 percent of the filled holes shall be bolted and tightened to snug-tight. Once all these bolts are snug-tight, each bolt shall be systematically tightened to the specified minimum tension. The fully tensioned bolts shall be located near the middle of a single field connection or a single splice plate.

Drift pins shall be placed throughout each field connection and each field joint with the greatest concentration in the outer edges of a splice plate or member being bolted.

To complete a joint following the method listed above, the Contractor shall fill all remaining holes of the field connection or splice plate with bolts and tighten to snug-tight. Once all of these bolts are snug-tight, each bolt shall be systematically tightened to the specified minimum tension. After these bolts are tightened to the specified minimum tension, the Contractor shall replace the drift pins with bolts tightened to the specified minimum tension.

The Contractor may complete a field bolted connection or splice in a continuous operation before releasing the mass of the member or adding the next member. The Contractor shall utilize drift pins to align the connection. The alignment drift pins shall fill between 15 and 30 percent of the holes in a single field connection and between 15 and 30 percent of the holes on each side of a single joint in a splice plate. Once the alignment drift pins are in place, all remaining holes shall be filled with bolts and tightened to snug-tight starting from near the middle and proceeding toward the outer gage lines. Once all of these bolts are snug-tight, the Contractor shall systematically tighten all these bolts to the specified minimum tension. The Contractor shall then replace the drift pints with bolts. Each of these bolts shall be tightened to the specified minimum tension.

All bolts shall be placed with heads toward the outside and underside of the bridge. All high-strength bolts shall be installed and tightened before the falsework is removed.

The Contractor may erect metal railings as erection proceeds. But railings shall not be bolted or adjusted permanently until the falsework is released and the deck placed.

The Contractor shall provide the Engineer advance notice for the Engineer's inspection of field bolting before beginning painting. Where bolted connections are shown on the Drawings or specifically authorized, all bolts, nuts, and washers shall conform to the specifications for material and assembly of structural joints using high strength steel bolts as provided in Division I, Design, Article 10.32.3, and Division II, Construction, Article 11.3.

6-03.3(33) BOLTED CONNECTIONS

6-03.3(33)A GENERAL

Bolts, nuts, hardened washers, and direct tension indicators shall meet the requirements of Section 9-06(5)3.

All bolted connections are slip critical bearings. Painted Structures require Type 1 or Type 2 bolts. Unpainted Structures require Type 3 bolts. AASHTO M 253, Types 1, 2, and 3 bolts shall not be galvanized or be used in contact with galvanized material.

Hardened washers are required under turned elements for connections using AASHTO M 164 and AASHTO M 253 bolts and as required in the following:

1. Irrespective of the tightening method, hardened washers shall be used under both the head and the nut when AASHTO M 253 bolts are to be installed in structural carbon steel, as specified in Section 9-06.1.
2. Where the outer face of the bolted ports has a slope greater than 1:20 with respect to a plane normal to the bolt axis, a hardened beveled washer shall be used to compensate for the lack of parallelism.

All galvanized nuts shall be lubricated with a lubricant containing a visible dye so a visual check for the lubricant can be made at the time of field installation. Black bolts shall be "oily" to the touch when installed. Weathered or rusted bolts and nuts shall be cleaned and relubricated prior to installation.

After assembly, bolted parts shall fit solidly together. Bolted parts shall not be separated by washers, gaskets, or any other material. Assembled joint surfaces, including those next to bolt heads, nuts, and washers, shall be free of loose mill scale, burrs, dirt, and other foreign material that would prevent solid seating.

Tightened bolts in a joint shall carry at least the proof load shown in the following Table 3:

Table 3

Minimum Bolt Tension

Bolt Size (Inches)	**AASHTO M 164** (Pounds)	**AASHTO M 253** (Pounds)
½	12,050	14,900
5/8	19,200	23,700
¾	28,400	35,100
7/8	39,250	48,500
1	51,500	63,600
1-1/8	56,450	80,100
1-1/4	71,700	101,800
1-3/8	85,450	121,300
1-1/2	104,000	147,500

Tightening may be done by either the turn-of-nut or the Direct-Tension-Indicator Method. Preferably, the nut shall be turned tight while the bolt is prevented from rotating. However, if required because of bolt entering and/or wrench operational clearances, tightening may be done by turning the bolt while the nut is prevented from rotating. Following are descriptions of the Turn-of-Nut and Direct-Tension-Indicator Methods:

1. **Turn-of-Nut Method:**

Hardened steel washers shall be used under the turned elements. After a bolt in a connection or joint splice plate has been tightened to snug-tight and meets all specified bolting conditions, it shall be tightened to the specified minimum tension by rotating the amount specified in the following Table 4. Before final tightening, the Contractor shall match-mark with crayon or paint the outer face of each nut and the protruding part of the bolt. To ensure that this tightening method is followed, the Engineer will (1) observe as the Contractor installs and tightens all bolts, and (2) inspect each match-mark.

Table 4

Turn-of-Nut Tightening Method
Nut Rotational from Snug-Tight Condition

Bolt Length	**Disposition of Outer Faces of Bolted Parts**		
	Condition 1	Condition 2	Condition 3
L ≤ 4D	1/3 turn	½ turn	2/3 turn
4D < L ≤ 8D	1/2 turn	2/3 turn	5/6 turn
8D < L ≤ 12D	2/3 turn	5/6 turn	1 turn

Bolt length measured from underside of head to extreme end of point.

Condition 1: both faces at right angles to bolt axis.
Condition 2: one face at right angle to bolt axis, one face sloped no more than 1:20, without bevel washer.
Condition 3: both faces sloped no more than 1:20 from right angle to bolt axis, without bevel washer.

Nut rotation is relative to the bolt regardless of which element (nut or bolt) is being turned.

Tolerances permitted: ± 30 degrees (1/12 turn) for final turns of 1/2 turn or less;
± 45 degrees (1/8 turn) for final turns of 2/3 turn or more.

D = nominal bolt diameter of bolt being tightened.

When bolt length exceeds 12D, the rotation shall be determined by actual tests in which a suitable tension device simulates actual conditions.

2. **Direct-Tension-Indicator Method**:

Direct Tension Indicators (DTIs) shall not be used under the turned element. DTIs shall be placed under the bolt head with the protrusions facing the bolt head when the nut is turned. DTIs shall be placed under the nut with the protrusions facing the nut when the bolt is turned.

DTIs shall be installed by 2 or more person crews with one individual preventing the element at the DTI from turning the measuring the gap of the DTI to determine the proper tension of the bolt.

Three DTIs, per lot, shall be tested in a WSDOT approved bolt tension calibrator. The bolts shall be tensioned to 105 percent of the tension shown in Table 3. The test bolts shall not be tightened such that all of the DTI protrusions are completely crushed (all five openings with zero gap). The DTI gap between all protrusions shall be measured with a tapered feeler gauge to the nearest 0.001 inch. All of the non-zero DTI gap measurements for the three test bolts shall be averaged. This average shall be used in the tightening of all the production bolts except as provided in the following:

All bolts in a connection shall be snug tightened prior to bringing any DTIs in the connection to full load. The maximum gap of the production bolt DTIs shall not be greater than the average test gap established above or 0.005 inch, whichever is less. The minimum gap of the production bolts DTIs may be zero (all five openings with zero gap).

The Contractor shall tension all bolts, inspecting all DTIs with a feeler gage, in the presence of the Engineer. The Contractor shall ensure the DTI does not rotate during bolt tightening.

If a bolt, that has had its DTI brought to full load, loosens during the course of bolting the connection, the bolt shall have a new DTI installed and be retensioned. Reuse of the bolt and nut are subject to the provisions of this Section.

AASHTO M 253 bolts and galvanized AASHTO M 164 bolts shall not be reused. Ungalvanized AASHTO M 164 bolts may be reused if the used nut on the used bolt can be turned for the full length of the bolt threads by hand. Bolts to be reused shall be relubricated. Used bolts shall be subject to a rotational capacity test as specified in Section 6-03.3(33)B Pre-Erection Testing. Touching up or retightening previously tightened bolts which may have been loosened by the tightening of adjacent bolts shall not be considered reused, provided the snugging up continues from the initial position and does not require greater rotation, including the tolerance, than that required by Table 4 in this Specification Section.

6-03.3(33)B PRE-ERECTION TESTING

High strength bolt assemblies (bolt, nut, and washer), black and galvanized, new and used as described in Section 6-03.3(33)A, shall be subjected to a rotational capacity test (AASHTO M 164, Section 8.5) prior to any erection activity. Each combination of bolt production lot, nut lot, and washer lot shall be tested as an assembly. All tests shall be performed by the Contractor in the presence of the Engineer. Two new specimens and two used specimens per lot shall be tested at the erection site immediately prior to installation or at a time during installation determined by the Engineer. The bolt assemblies shall meet the following requirements:

1. Go through two times the required number of turns from snug tight condition as indicated in Table 4 of Section 6-03.3(33)A without stripping, tensile, or shear failure. Rotation-capacity test shall be performed in a WSDOT approved bolt tension calibrator.
2. The maximum recorded tension shall be equal to or greater than 1:15 times the minimum bolt tension listed in Table 3 of Section 6-03.3(33)A.
3. The measured torque to produce the minimum bolt tension shall not exceed the value obtained by the following equation.

Torque = 0.25 PD

Where:	Torque	= Calculated Torque (foot-pounds)
	P	= Measured Bolt Tension (pounds)
	D	= Normal Bolt Diameter (feet)

4. Disassemble the torqued bolt and inspect for signs of failure. Failure is defined as any shear damage to the threads of the bolt or the nut or cracks in the body of the bolt. If either specimen fails, the lot of bolts will be rejected. Elongation of the bolt between the bolt head and the nut is not considered to be a failure.

6-03.3(33)C BOLTING INSPECTION

The Contractor, in the presence of the Engineer, shall inspect the tightened bolt using a calibrated inspection torque wrench. Torque wrench calibration shall be within the last six months.

If the bolts to be installed are not long enough to fit in the Owner furnished tension calibrator, five bolts of the same grade, size and condition as those under inspection shall be selected by the Contractor in the presence of the Engineer and shall be tested using Direct-Tension-Indicators (DTI) to measure bolt tension. This tension measurement test shall be done at least once each inspection day. The Contractor shall supply the necessary DTIs. The DTI shall be placed under the bolt head. A washer shall be placed under the nut, which shall be the element turned during the performance of this tension measurement test. Each bolt shall be tightened by any convenient means to the specified minimum tension as indicated by the DTI. The inspecting wrench shall then be applied to the tightened bolt to determine the torque required to turn the nut 5 degrees (approximately 1 inch at a 12-inch radius) in the tightening direction. The job inspection torque shall be tested five times. The high and low values shall be discarded and the job-inspection torque shall be the average of the remaining three middle values.

Five bolts selected by the Contractor in the presence of the Engineer of the same grade, size, and condition as those under inspection shall be placed individually in an Owner furnished tension calibrator to measure bolt tension. This calibration operation shall be done at least once each inspection day. There shall be a washer under the part turned in tightening each bolt if washers are used on the structure. In the calibrated device, each bolt shall be tightened by any convenient means to the specified tension. The inspecting wrench shall then be applied to the tightened bolt to determine the torque required to turn the nut or head 5 degrees (approximately 1 inch at a 12 inch radius) in the tightening direction. The job-inspection torque shall be tested five times. The high and low values shall be discarded and the job-inspection torque shall be the average of the remaining three middle values.

Ten percent (minimum 2 bolts) of the tightened bolts on the structure represented by the test bolts shall be selected at random in each connection. The job-inspection torque shall then be applied to each with the inspecting wrench turned in the tightening direction. The connection will be considered acceptable tightened if this job-inspection torque turns no bolt head or nut. However, if the torque turns one or more bolt heads or nuts, the job-inspection torque shall then be applied to all bolts in the connection. Any bolt whose head or nut turns at this stage shall be tightened and reinspected. The Contractor may, however, retighten all the bolts in the connection and resubmit it for inspection.

6-03.3(34) ADJUSTING PIN NUTS

All pin nuts shall be tightened thoroughly. The pins shall be placed so that members bear fully and evenly on the nuts. The pins shall have enough thread to allow burring after the nuts are tightened.

6-03.3(35) SETTING ANCHOR BOLTS

Anchor bolts shall be set in masonry as required in Section 6-02.3(18). Anchor bolts shall be grouted in after the shoes, bearing plates, and keeper plates have been set and the span or series of continuous spans are completely erected and adjusted to line and camber.

6-03.3(36) SETTING AND GROUTING BEARING PLATES

The following procedure applies to steel bearing plates for all steel spans, including shoes, keeper plates and turning racks on movable bridges.

To set bearing plates, the Contractor shall:

1. Set bearing plates on the anchor bolts;
2. Place steel shims under the bearing plates to position pin centers to line and grade and in relationship to each other. Steel shims shall be no more than 2-1/2 inches square and placed under bearing plates;
3. Level the bases of all bearing plates;
4. Draw anchor bolt nuts down tight;
5. Recheck pin centers or bearings for alignment; and
6. Leave at least 3/4 inch of space under each bearing plate for grout.

After the bearing plates have been set and the span or series of continuous spans are completely erected and swung free, the space between the bottom of the bearing plate and the top of the concrete bearing seat shall be filled with grout. Main bearing plates for cantilever spans shall be set and grouted in before any steel work is erected.

Grout mixture and placement shall be as required in Section 6-02.3(20).

6-03.3(37) SETTING STEEL BRIDGE BEARINGS

Bearing plates, shoes, and keeper plates of expansion bearings shall be set and adjusted to center the expansion shoe at a normal temperature of 64°F. Adjustment for any inaccuracy in fabricated length shall be made after dead-load camber is out.

6-03.3(38) PLACING SUPERSTRUCTURE

The Contractor shall place no superstructure load on finished piers or abutments until the Engineer allows. Normally, this concrete-hardening interval requires at least 12 days.

6-03.3(39) SWINGING THE SPAN

No forms, steel reinforcing bars, or concrete roadway slabs shall be placed on steel spans until the spans swing free on their supports and elevations are recorded. No simple span or any series of continuous spans will be considered as swinging free until all temporary supports have been released. Forms, reinforcing steel, or concrete roadway slabs shall not be placed on any simple or continuous span steel girder bridge until all its spans are adjusted and its bearing plates, shoes, and keeper plates grouted. For this Specification, the structure shall be considered to be continuous across hinged joints.

After the falsework is released (spans swung free), the bearing plates, shoes, and keeper plates are grouted, and before any load is applied, the Engineer will:

1. Measure elevations at selected points along the tops of girders or floorbeams under steel weight dead load;
2. Compare the calculated steel weight camber elevations with the elevations measured in step 1; and
3. Furnish the Contractor with new dead-load camber dimension.

The Contractor shall adjust the top-of-web to top-of-deck dimensions, varying from Drawing camber as necessary and as determined by the Engineer.

6-03.3(40) DRAINING POCKETS

The Contractor shall provide enough holes to drain all water from pockets in trusses, girders, and other members. Unless shown on submitted and reviewed by Engineer Shop Drawings, drain holes shall not be drilled without the written review of the Engineer.

6-03.3(41) FLOORBEAM PROTECTION

Each floorbeam that supports a concrete slab joint shall be coated on its top and flange edges with a heavy mop of roofing grade asphalt applied hot. This asphalt shall conform to ASTM D 312 (not mineral stabilized). A protective covering of asphalt coated glass fiber sheet (ASTM D 4601, Type 1, non-perforated) shall be placed over the hot coat of asphalt. This combination coating shall be applied over the shop paint. It shall take the place of the two field coats of paint specified for other parts of the structural steel. The second and third coats are acceptable exceptions and shall comply with Section 6-07.3(1)B.

6-03.3(42) SURFACE CONDITION

As the Structure is erected, the Contractor shall keep all steel surfaces clean and free from dirt, concrete, mortar, oil, paint, grease, and other stain-producing foreign matter. Any surfaces that become stained shall be cleaned as follows:

1. Painted steel surfaces shall be cleaned by methods required for the type of staining. The method shall be submitted to the Engineer for approval; and
2. Unpainted steel surfaces shall be cleaned by sandblasting. Sandblasting to remove stains on publicly visible surfaces shall be done to the extent that, in the Engineer's opinion, the uniform weathering characteristics of the Structure are preserved.

6-03.3(43) CASTINGS, STEEL FORGINGS, AND MISCELLANEOUS METALS

6-03.3(43)A GENERAL

Castings, steel forgings, and miscellaneous metals shall be built to comply with Section 9-06.

6-03.3(43)B SHOP CONSTRUCTION, CASTINGS, STEEL FORGINGS, AND MISCELLANEOUS METALS

This Section's requirements for structural steel (including painting requirements) shall also apply to castings, steel forgings, and miscellaneous metals.

Castings shall be:

1. True to pattern in form and dimensions;
2. Free from pouring faults, sponginess, cracks, blow holes, and other defects in places that would affect strength, appearance, or value;
3. Clean and uniform in appearance;
4. Filleted boldly at angles; and
5. Formed with sharp and perfect arises.

Iron and steel castings and forgings shall be annealed before any machining, unless indicated otherwise in the Contract.

6-03.4 MEASUREMENT

Bid items of work completed pursuant to the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs herein this Section.

Cast or forged metal (kind) or copper seals shown on the Drawings will be measured by the pound or will be paid for on a lump sum basis as shown on the Bid Form.

In computing pay weight on the basis of scale weights, the pay quantity of structural steel will be the shop scale weight of the fabricated members weighed on scales meeting the requirements of Section 1-09.2 in the presence of the Engineer. If the shop paint has been applied to the completed member when weighed, 0.4 of 1 percent of the weight of the member shall be deducted from the scale weights to compensate for weight of shop paint.

6-03.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-03 will be made at the Bid item prices Bid only for the Bid items listed or referenced as follows:

1. **"Structural Carbon Steel",** per pound.
2. **"Structural Low Alloy Steel",** per pound.
3. **"Structural High Strength Steel",** per pound.

The Bid item prices Bid for the Bid items "Structural Carbon Steel", "Structural Low Alloy Steel", and "Structural High Strength Steel" shall include all costs for the work required for manufacture, fabrication, transportation, erection, welding inspection, and painting of all structural steel used in the completed structure, including protective coating or treatment as may be called for in the Contract.

For the purpose of payment, such minor items as bearing plates, pedestals, forged steel pins, anchor bolts, field bolts, shear connectors, etc., shall not be considered as structural carbon steel even though it is made of other materials.

All costs related to inspection of structural welds shall be included in the Bid item price Bid for structural steel and shall, in each case, refer to the appropriate inspection method necessary for obtaining optimum quality assurance and shall be at no additional cost to the Owner.

4. **"(Cast or Forged) Steel",** lump sum or per pound.
5. **"(Cast, Malleable, or Ductile) Iron",** lump sum or per pound.
6. **"Cast Bronze",** lump sum or per pound.

The Bid item prices for "(Cast or Forged) Steel", for "(Cast, Malleable or Ductile) Iron", and for "Cast Bronze" shall include all costs for the work required to furnish and install the Material as specified.

7. **Other payment information.**

When no Bid item is included in the Bid Form and payment is not otherwise provided, the castings, forgings, and miscellaneous metal shall be considered as incidental to the construction, and all costs therefore shall be included in the Bid item prices for the Bid items involved and shall be at no additional or separate expense to the Owner.

Prospective Bidders shall verify the estimated weight of structural steel before submitting the Bid.

All costs related to filling pockets shall be included in the Bid item prices for structural or cast steel and shall be at no additional or separate expense to the Owner.

The weight of field bolts shall be based on the Engineer reviewed shipping list. No payment will be made for any weight in excess of 1-1/2 percent above the computed net weight of the whole item.

Reinforcing bars which are threaded will be paid as “Steel Reinforcing Bar, (Grade)” or “Steel Reinforcing Bar, (Grade), Epoxy Coated” in accordance with Section 6-02.5.

All costs related to providing drain holes shall be included in the Bid item prices for structural or cast steel and shall be at no additional or separate expense to the Owner.

All costs related to providing drain holes per Section 6-03.3(40) shall be included in the Bid item prices for structural or cast steel and shall be at no additional or separate expense to the Owner.

SECTION 6-04 TIMBER STRUCTURES

6-04.1 DESCRIPTION

Section 6-04 addresses the work of building of any Structure or parts of Structures (except piles) made of treated timber, untreated timber, or both. The Contractor shall erect timber structures on prepared foundations. The Structures shall conform to the dimensions, lines, and grades required by the Drawings, the Engineer, and these Standard Specifications.

Any part of a timber structure made of nontimber Materials shall comply with the sections of the Standard Specifications that govern those Materials.

6-04.2 MATERIALS

Materials shall meet the requirements of the following Sections:

Structural Steel and Related Material	9-06
Paints	9-08
Timber and Lumber	9-09

6-04.3 CONSTRUCTION REQUIREMENTS

6-04.3(1) STORING AND HANDLING MATERIAL

At the Project Site, the Contractor shall store all timber and lumber in stacked piles. Weeds and rubbish under and around these piles shall be removed before the lumber is stacked.

Untreated lumber shall be open stacked at least 12 inches above the ground and shall be piled to shed water and prevent warping.

Treated timber shall be:

1. Cut, framed, and bored (whenever possible) before treatment;
2. Close stacked and piled to prevent warping;
3. Covered against the weather to prevent warping or deterioration;
4. Handled carefully to avoid sudden drops, broken outer fibers, and surface penetration or bruising with tools; and
5. Lifted and moved with rope and chain slings (without using cant dogs, peaveys, hooks, or pike poles).

6-04.3(2) WORKMANSHIP

See Section 1-05.13. Poor workmanship includes deep hammer marks in wood surfaces. Workmanship on metal parts shall comply with requirements of Section 6-03.

6-04.3(3) SHOP DRAWINGS

The Contractor shall provide the Engineer with six sets of Shop Drawings for all Structures built with treated timber. These Shop Drawings shall show dimensions for all cut, framed, or bored timbers.

The Engineer will return to the Contractor one set of reviewed Shop Drawings. No material shall be framed or bored until the Engineer has completed review of the Shop Drawings. Shop Drawings shall be drawn on sheets that conform to the sizes required in Section 1-05.3(10)B.

6-04.3(4) FIELD TREATMENT OF CUT SURFACES, BOLT HOLES, AND CONTACT SURFACES

All cut surfaces, bolt holes, and contact surfaces shall be treated in accordance with Section 9-09.3 for all timber and lumber requiring preservative treatment.

All cuts and abrasions in treated timber piles or treated timbers shall be trimmed carefully and treated again at the cut or abrasion in accordance with Section 9-09.3.

6-04.3(5) HOLES FOR BOLTS, DOWELS, RODS, AND LAG SCREWS

Holes shall be bored:

1. For drift pins and dowels: with a bit 1/16 inch smaller in diameter than the pins and dowels.
2. For truss rods or bolts: with a bit the same diameter as the rods or bolts.
3. For lag screws in two parts:
   (a) with the shank lead hole the same diameter as the shank and as deep as the unthreaded shank is long; and
   (b) with the lead hole for the threaded part approximately two thirds of the shank diameter.

6-04.3(6) BOLTS, WASHERS, AND OTHER HARDWARE

Bolts, flat-head bolts, dowels, washers, and other hardware, including nails, shall be black or galvanized as specified on the Drawings. Hardware not otherwise specified shall be galvanized when used in treated timber Structures. Flat-head bolts are detailed in the Standard Plans.

Washers of the size and type specified shall be used under all bolt heads and nuts that contact wood. Flat-head bolts require washers under the nuts only.

All bolts shall be checked by burring the threads after the nuts have been finally tightened. Vertical bolts shall have nuts on the lower ends.

Wherever bolts fasten timber to timber, timber to concrete, or timber to steel, the members shall be bolted tightly together at installation and retightened just before the Owner accepts the Work. These bolts shall have surplus threading of at least 3/8 inch per foot of timber thickness to permit future tightening.

6-04.3(7) COUNTERSINKING

Countersinking shall be done wherever smooth faces are indicated in the Contract. Each recess shall be treated in accordance with Section 9-09.3.

6-04.3(8) FRAMING

The Contractor shall cut and frame lumber and timber to produce close-fitting, full-contact joints. Each mortise shall be true to size for its full depth, and its tenon shall fit it snugly. Neither shimmed nor open joints are permitted.

6-04.3(9) FRAMED BENTS

Mudsills shall be of pressure-treated timber, firmly and evenly bedded to solid bearing, and tamped in place.

Concrete pedestals that support framed bents shall be finished so that sills bear evenly on them. To anchor the sills, the Contractor shall set dowels in the pedestals when they are cast. The dowels shall be at least 3/4 inch in diameter and protrude at least 6 inches above the pedestal tops. Pedestal concrete shall comply with Section 6-02.

Each sill shall rest squarely on mudsills, piles, or pedestals. It shall be drift-bolted to mudsills or piles with 3/4 inch diameter or larger bolts that extend at least 6 inches into the mudsill or pile. The Contractor shall ensure no earth touches the sills and that free air circulation surrounds them.

Each post shall be fastened to sills with 3/4 inch diameter or larger dowels that extend at least 6 inches into the post.

6-04.3(10) CAPS

Timber caps shall rest uniformly across the tops of posts or piles and cap ends shall be aligned evenly. Each cap shall be fastened with a drift bolt 3/4 inch in diameter or larger that penetrates the post or pile at least 9 inches. The bolt shall be approximately in the center of the pile or post.

If the roadway grade exceeds 2 percent, each cap shall be beveled to match the grade.

6-04.3(11) BRACING

When pile bents are taller than 10 feet, each bent shall be braced transversely. Every other pair of bents shall be braced longitudinally. No single cross-bracing shall brace more than 20 feet of vertical distance on the piles. More than one cross-bracing shall be used if the vertical distance exceeds 20 feet. Each brace end shall be bolted through the pile, post, or cap with a bolt at least 3/4 inch in diameter. Other brace/pile intersections shall be bolted or boat-spiked as indicated on the Drawings. Cross-bracing shall lap both upper or lower caps and shall be bolted to the caps or sills at each end.

6-04.3(12) STRINGERS

All stringers that carry laminated decking or vary more than 1/8 inch in depth shall be sized to an even depth at bearing points. Outside stringers shall be butt jointed and spliced.

Interior stringers shall be lapped so that each rests over the full width of the cap or floorbeam at each end. Stringers may cover two spans except on sharp horizontal and vertical curves. In this case, joints shall be staggered and the stringers either toenailed or drift bolted as indicated in the Contract. To permit air circulation on untreated timber structures, the ends of lapped stringers shall be separated. This separation shall be done by fastening across the lapping face a 1-inch by 3-inch wood strip cut 2 inches shorter than the depth of the stringer.

Any cross-bridging or solid bridging shall be neatly and accurately framed, then securely toenailed at each end (with two nails for cross-bridging and four nails for solid bridging). The Drawings show bridging size and spacing.

6-04.3(13) TIMBER WHEEL GUARDS AND TIMBER RAILINGS

Timber wheel guards and timber railings shall follow the construction requirements of Section 6-06.3(1). Construction methods not addressed in Section 6-06.3(1) shall follow the construction requirements of Section 6-04.

6-04.3(14) SINGLE-PLANK FLOORS

Single-plank floors shall be made of a single thickness of plank on stringers or joists.

The planks shall be:

1. Laid heart side down with tight joints;
2. Spiked to each joist or nailing strip with at least two spikes that are at least 4 inches longer than the plank thickness;
3. Spiked at least 2 1/2 inches from the edges;
4. Cut off on a straight line parallel to the centerline of the roadway;
5. Arranged so that no adjacent planks vary in thickness by no more than 1/16 inch; and
6. Surfaced on one side and one edge (S1S1E) unless otherwise specified in the Contract.

6-04.3(15) LAMINATED FLOORS

The strips shall be placed on edge and shall be drawn down tightly against the stringer or nailing strip and the adjacent strip and, while held in place, shall be spiked. Each strip shall extend the full width of the deck, unless otherwise indicated in the Contract.

Each strip shall be spiked to the adjacent strip at intervals of not more than 2 feet, the spikes being staggered 8 inches in adjacent strips. The spikes shall be of sufficient length to pass through two strips and at least halfway through the third. In addition, unless bolting is specified in the Contract, each strip shall be toenailed to alternate stringers with 40d common nails and adjacent strips shall be nailed to every alternate stringer. The ends of all pieces shall be toenailed to the outside stringer. The ends of the strips shall be cut off on a true line parallel to the centerline of the roadway. When bolts are used to fasten laminated floors to stringers, the bolts shall be placed at the spacing shown in the Contract, and the pieces shall be drawn down tightly to the bolting strips. The bolt heads shall be driven flush with the surface of the deck. Double nuts or single nuts and lock nuts shall be used on all bolts. The strips shall be spiked together in the same manner as specified above.

6-04.3(16) PLANK SUBFLOORS FOR CONCRETE DECKS

Any plank subfloor shall be laid surfaced side down with close joints at right angles to the centerline of the roadway. Planks shall be spiked in place as required in Section 6-04.3(14).

Floor planks shall be treated as Section 9-09.3 requires.

6-04.3(17) TRUSSES

Completed trusses shall show no irregularities of line. From end to end, chords shall be straight and true in horizontal projection. In vertical projection they shall show a smooth curve through panel points that conforms to the correct camber. The Engineer will reject any pieces cut unevenly or roughly at bearing points. Before the Contractor places the hand railing, the Contractor shall complete all trusses, swing them free of their falsework, and adjust them for line and camber.

6-04.3(18) PAINTING

See Section 6-07.3(3) for painting of timber Structures.

6-04.4 MEASUREMENT

Bid items of work completed pursuant to the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual m easurement paragraphs herein this Section.

The criteria in Section 6-03.4 will be used to determine the weight of structural metal other than hardware.

Timber and lumber (treated or untreated) will be measured by the 1,000 board feet (MBM), using nominal thicknesses and widths. Lengths will be actual lengths of individual pieces in the finished structure with no deduction for daps, cuts, or splices. To measure laminated timber decking, the Engineer will use the number and after-dressing sizes of pieces required on the Drawings. The length of each lamination shall be the length remaining in the finished Structure.

6-04.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-04 will be made at the Bid item prices Bid only for the Bid items listed or referenced as follows:

1. "**Timber and Lumber (untreated or name treatment)**", per MBM.
2. "**Structural Metal**", lump sum.

Where no Bid item for structural metal is included in the proposal, full pay for furnishing and placing metal parts shall be included in the Bid item price per MBM for "Timber and Lumber (untreated or name treatment)".

SECTION 6-05 PILES

6-05.1 DESCRIPTION

Section 6-05 describes work consisting of furnishing and driving piles (timber, precast concrete, cast-in-place concrete, and steel) of the sizes and types indicated in the Contract require. This work also includes cutting off or building up piles when required.

6-05.2 MATERIALS

Materials shall meet the requirements of the following sections:

Reinforcing Steel	9-07
Prestressing Steel	9-07.10
Piles	9-10

6-05.3 CONSTRUCTION REQUIREMENTS

6-05.3(1) PILE TERMS

Allowable Bearing Capacity — Allowable bearing capacity is the ultimate bearing capacity divided by a factor of safety. The Contract may state the factor of safety to be used in calculating the allowable bearing capacity from the ultimate bearing capacity. In the absence of a specified factor of safety, a value of three (3) shall be used.

Auger Cast-In-Place Piles – Auger cast-in-place piles are auger drilled soil penetrations to the limits called for in the Contract and then filled with concrete as the auger is removed. A steel cage is typically inserted in the concrete after the concrete is placed.

Concrete Piles — Concrete piles may be precast or precast-prestressed driven to the limits called for in the Contract. Concrete piles may also be steel casings driven to limits called for in the Contract and then filled with concrete after driving.

Developed Hammer Energy — The developed hammer energy is the actual amount of gross energy produced by the hammer for a given blow. This value shall never exceed the rated hammer energy. The developed energy may be calculated as the ram weight times the drop (or stroke) for drop, single acting hydraulic, single acting air/steam, and open-ended diesel hammers. For double acting hydraulic and air/steam hammers, the developed hammer energy shall be calculated from ram impact velocity measurements or other means approved by the Engineer. For closed-ended diesel hammers, the developed energy shall be calculated from the measured bounce chamber pressure for a given blow. Hammer manufacturer calibration data may be used to correlate bounce chamber pressure to developed hammer energy. For a single acting diesel hammer the developed energy is determined using the blows per minute.

Follower — A follower is a structural member placed between the hammer assembly, which includes the helmet, and the pile top when the pile top is below the reach of the hammer.

Hammer cushion — The hammer cushion is a disk of material placed on top of the helmet but below the anvil or striker plate to relieve impact shock, thus protecting the hammer and the pile.

Helmet — The helmet, also termed the cap, drive cap, or driving head, is used to transmit impact forces from the hammer ram to the pile top as uniformly as possible across the pile top such that the impact force of the ram is transmitted axially to the pile. The term helmet can apply to the complete impact force transfer system, which includes the anvil or striker plate, hammer cushion and cushion block, and a pile cushion if used, or just the single piece unit into which these other components (anvil, hammer cushion, etc.) fit. The helmet does not include the follower, if one is used. For hydraulic hammers, the helmet is sometimes referred to as the anvil.

Maximum Driving Resistance — The maximum driving resistance is either the pile ultimate bearing capacity, or ultimate bearing capacity plus overdriving to reach minimum tip elevation is specified in the Contract, whichever is greater.

Minimum Tip Elevation — The minimum tip elevation is the elevation to which the pile tip shall be driven. Driving deeper in order to obtain the required bearing capacity may be required.

Overdriving — Over-driving of piles occurs when the ultimate bearing capacity calculated from the equation in Section 6-05.3(12), or the wave equation if applicable, exceeds the ultimate bearing capacity required in the Contract in order to reach the minimum tip elevation specified in the Contract, or as required by the Engineer.

Pile Cushion — The pile cushion is a disk of material placed between the helmet and the pile top to relieve impact shock, primarily to protect the pile.

Pile Driving Analyzer — A pile driving analyzer (PDA) is a device which can measure the transferred energy of a pile driving system, the compressive and tensile stresses induced in the pile due to driving, the bending stresses induced by hammer misalignment with the pile, and estimate the ultimate capacity of a pile at a given blow.

Pile Driving Refusal — Pile driving refusal is defined as 15 blows per inch for the last 4 inches of driving. This is the maximum blow count allowed during overdriving.

Pile Driving System — The pile driving system includes, but is not necessarily limited to, the hammer, leads, helmet or cap, cushion and pile.

Pile Head – The end of the pile struck by the hammer for driving. Also known as head, head end, butt, butt end, and pile top.

Pile Shoe - A hard metal tip secured to the driving end of a pile for protecting the pile tip during penetration into the soil.

Pile Tip – The penetrating end of the pile opposite the pile head where end bearing may occur. Also known as tip.

Rated Hammer Energy — The rated energy represents the theoretical maximum amount of gross energy that a pile driving hammer can generate. The rated energy of a pile driving hammer shall be stated in the hammer manufacturer's catalog or specifications for that pile drive hammer.

Steel Piles — Open-ended or closed-ended pipe piles, or H-piles.

Transferred Hammer Energy — The transferred hammer energy is the amount of energy transferred to the pile for a given blow. This value shall never exceed the developed hammer energy. Factors that cause transferred hammer energy to be lower than the developed hammer energy include friction during the ram downstroke, energy retained in the ram and helmet during rebound, and other impact losses. The transferred energy can only be measured directly by use of sensors attached to the pile. A pile driving analyzer (PDA) may be used to measure transferred energy.

Ultimate Bearing Capacity — Ultimate bearing capacity refers to the vertical load carrying capacity (in units of force) of a pile as determined by the equation in Section 6-05.3(12), the wave equation analysis, pile driving analyzer and CAPWAP, static load test, or any other means as may be required by the Contract.

Wave Equation Analysis — Wave equation analysis is an analysis performed using the wave equation analysis program (WEAP) with a version dated 1987 or later. The wave equation may be used as specified herein to verify the Contractor's proposed pile driving system. The pile driving system includes, but is not necessarily limited to, the pile, the hammer, the helmet, and any cushion. The wave equation may also be used by the Engineer to determine pile driving criteria as may be required in the Contract.

6-05.3(2) ORDERING PILES

The length of piles given in the Bid Form is for estimating purposes only and is not to be used as an order list.

No order list for piles will be furnished by the Engineer.

All piles shall be ordered by the Contractor. The Contractor shall determine the length required from the results obtained by the driving of the test piles called for in the Contract, and from subsurface exploration data. The Contractor shall increase the lengths, at no additional cost to the Owner, the necessary amount to provide for fresh heading and to reach from the cutoff elevation up to the position of the driving equipment.

See Section 6-05.3(10) regarding test piles.

6-05.3(3) CONCRETE PILES

6-05.3(3)A MANUFACTURE OF PRECAST CONCRETE PILES

Precast concrete piles shall consist of concrete sections reinforced to withstand handling and driving stresses. These may be reinforced with deformed steel bars or prestressed with steel strands. The Drawings show dimensions and details. If the Drawings require piles with square cross-sections, the corners shall be chamfered 1 inch.

13-inch diameter precast or prestressed piles shall meet the requirements of WSDOT Standard Plan no. E-4.

16-inch and 18-inch diameter precast-prestressed piles shall meet the requirements of WSDOT Standard Plan no. E-4a.

Temporary stress in the prestressing reinforcement of prestressed piles (before loss from creep and shrinkage) shall be 70 percent of the minimum ultimate tensile strength. (For short periods during manufacture, the reinforcement may be overstressed to 80 percent of ultimate tensile strength if stress after transfer to concrete does not exceed 70 percent of that strength.)

Prestressed concrete piles shall have a final (effective) prestress of at least 1,000 psi.

Unless the Engineer approves splices, all piles shall be full length.

The Engineer intends to perform inspection in accordance with Section 1-06.1.

6-05.3(3)B CASTING AND STRESSING

Reinforcing bars, hoops, shoes, etc. shall be placed as shown in the Contract. All parts shall be securely tied together and placed to the specified spacings. No concrete shall be placed until all reinforcement is in place and the forms are secured.

The Contractor shall perform quality control inspection. The manufacturing plant for precast concrete piles shall be certified by the Precast/Prestressed Concrete Institute's Plan Certification Program for the type of precast piles that is to be produced and shall be approved by WSDOT as a Certified Precast Concrete Fabricator prior to start of production.

Prior to the start of production of the piles, the Contractor shall provide the Engineer advance notification of the production schedule. The Engineer may inspect the fabrication of concrete piles in accordance with Sections 1-05 and 1-06.

In casting concrete piles, the Contractor shall:

1. Cast them either vertically or horizontally;
2. Use metal forms with smooth joints and inside surfaces that can be thoroughly cleaned after each use;
3. Brace and stiffen the forms to prevent distortion;
4. Place concrete continuously in each pile, guarding against horizontal or diagonal cleavage planes;
5. Ensure that the reinforcement is properly embedded;
6. Use internal vibration around the reinforcement during concrete placement to prevent rock pockets from forming; and
7. Cast test cylinders with each set of piles as concrete is placed.

Forms shall be metal and shall be braced and stiffened to retain their shape under pressure of wet concrete. Forms shall have smooth joints and inside surfaces easy to reach and clean after each use. That part of a form which shapes the end surface of the pile shall be a true plane at right angles to the pile axis.

Each pile shall contain a cage of nonprestressed reinforcing steel sized and located as indicated on the Drawings. Spiral steel reinforcing shall be secured in position and shall have a minimum 1-1/2 inch concrete cover from the outside pile surface.

Prestressing steel shall be tensioned as required in Section 6-02.3(25)D.

The Drawings specify tensioning stress for strands or wires. Tension shall be measured by jack pressure as described in Section 6-02.3(25)D. Mechanical locks or anchors shall temporarily maintain cable tension. All jacks shall have hydraulic pressure gauges (accurately calibrated and accompanied by a certified calibration curve no more than 180 days old) that permit stress calculations at all times.

All tensioned piles shall be pretensioned. Post-tensioning is not allowed.

The Contractor shall not stress any pile until test cylinders made with it reach a compressive strength of at least 3,300 psi.

6-05.3(3)C FINISHING

As soon as the forms for each precast concrete pile is removed, the Contractor shall fill all holes and irregularities in the pile with 1:2 mortar. That part of any trestle pile that is to be underground or below the low-water line and all parts of any pile to be used in salt water or alkaline soil shall receive only this mortar treatment. That part of any trestle pile that shows above the ground or water line shall be given a Class 3 finish as described in Section 6-02.3(14)D.

6-05.3(3)D CURING

Precast Concrete Piles. The Contractor:

1. Shall keep the concrete continuously wet with water after placement for at least ten days with Type I or II Portland cement or at least three days with Type III;
2. Shall remove side forms no sooner than 24 hours after concrete placement, and then only if the surrounding air remains at no less 50°F for five days with Type I or II Portland cement or three days with Type III; and
3. May cure precast piles with saturated steam or hot air, as described in Section 6-02.3(25)E, provided the piles are kept continuously wet until the concrete has reached a compressive strength of 3,300 psi.

Precast-Prestressed Concrete Piles. These piles shall be cured as required in Section 6-02.3(25)E.

6-05.3(4) MANUFACTURE OF STEEL CASINGS FOR CAST-IN-PLACE CONCRETE PILES

The diameter of steel casings shall be as specified in the Contract. Spiral welded steel pile casings are not allowed for steel pile casings greater that 24 inches in diameter. A full penetration groove weld with a maximum 1/16 inch offset between welded edges is required.

6-05.3(5) MANUFACTURE OF STEEL PILES

Steel piles shall be made of rolled steel H-pile sections, steel pipe piles, or of other structural steel sections described in the Contract. Spiral welded steel pile casings are not allowed for steel pipe piles greater than 24 inches in diameter. A full penetration groove weld with a maximum 1/16 inch offset between welded edges is required.

6-05.3(6) SPLICING STEEL CASINGS AND STEEL PILES

The Engineer will normally permit steel piles and steel casings for cast-in-place concrete piles to be spliced. However, the Contractor shall obtain the Engineer's advance approval on the need and the method for splicing. Welded splices shall be spaced at a minimum distance of *10 feet*. Only welded splices will be permitted.

Splice welds shall comply with Section 6-03.3(25) and AWS D1.1 Structural Welding Code. Splicing of steel piles shall be performed in accordance with an approved weld procedure. The Contractor shall submit a weld procedure to the Engineer for approval prior to welding. For ASTM A 252 Material, mill certification for each lot of pipe to be welded shall accompany the submittal.

Weld splicing of steel casings for cast-in-place concrete piles shall be the Contractor’s responsibility. Casings that collapse or are not watertight, shall be replaced at no additional cost to the Owner.

Steel casing joints shall not be offset more than 1/16 inch.

6-05.3(7) STORAGE AND HANDLING

The Contractor shall store and handle piles in ways that protect them from damage.

6-05.3(7)A TIMBER PILES

Timber piles shall be stacked closely and in a manner to prevent warping. The ground beneath and around stored piles shall be cleared of weeds, brush, and rubbish. Piles shall be covered against the weather if the Engineer requires it.

The Contractor shall take special care to avoid breaking the surface of treated piles. Piles shall be lifted and moved with rope or chain slings (without the use of cant dogs, peaveys, hooks, or pike poles). If timber piles are rafted, any attachments shall be within 3 feet of the butts or tips. Any surface cut or break shall be brushed with two coats of creosote oil and covered with an approved roofing asphalt. The Engineer may reject any pile because of a cut or break.

6-05.3(7)B PRECAST CONCRETE PILES

The Contractor shall not handle any pile until test cylinders made with the same batch of concrete as the pile reach a compressive strength of at least 3,300 psi.

Storing and handling methods shall protect piles from fractures by impact and undue bending stresses. Handling methods shall never stress the reinforcement more than 12,000 psi. An allowance of twice the calculated load shall be made for impact and shock effects. The method of lifting the piles shall be submitted to the Engineer for approval. The Contractor shall take extra care to *not* damage the surface of any pile to be used in sea water or alkaline soil.

6-05.3(7)C STEEL CASINGS AND STEEL PILES

The Engineer will reject bent, deformed, or kinked piles.

6-05.3(8) PILE TIPS AND SHOES

Timber piles shall be driven with squared ends unless subsurface conditions require attaching metal shoes. Pile tips and shoes shall be securely attached to the piles in accordance with the manufacturer's recommendations.

When required in the Contract, conical steel pile tips shall be used when driving steel casings. The tips shall be inside fit, flush-mounted such that neither the tip nor weld bead protrudes more than 1/16 inch beyond the nominal outside diameter of the steel casing.

If conical tips are not required in the Contract, the lower end of each casing shall have a steel driving plate that is thick enough to keep the casing watertight and free from distortion as it is driven. The diameter of the steel driving plate shall not be greater than the outside diameter of the steel casing.

Where called for in the Contract, inside-fit cutting shoes shall be used when driving open-ended steel piles. The cutting shoes shall be flush-mounted such that neither the shoe nor the weld bead protrudes more than 1/16 inch beyond the nominal outside diameter of the steel pile. The cutting shoe shall be of an inside diameter at least 0.75 inch less than the nominal inside diameter of the steel pile.

The Contractor shall submit to the Engineer for approval, Shop Drawings of the proposed pile tip or shoe along with design calculations, specifications, material chemistry and installation requirements, and shall also be prepared to provide a pile driving test demonstrating suitability of the proposed pile tip. The test shall be performed in the presence of the Engineer or an acceptable to the Engineer independent AASHTO certified testing agency, and shall consist of driving a pile fitted with the proposed tip. The pile shall be located outside the proposed foundation limits if the pile cannot be visually inspected (see Section 6-05.3(11)F). The pile shall be driven to a depth sufficient to develop the required bearing capacity specified in the Contract and in ground conditions determined by the Engineer to be equivalent to the ground conditions at the Project Site. For closed-ended casings or piles, the pile need not be removed if, in the opinion of the Engineer, the pile can be evaluated for evidence of damage to the pile or the tip. For open-ended steel casings or piles, timber piles or H-piles, the pile shall be removed for evaluation.

6-05.3(9) PILE DRIVING EQUIPMENT

6-05.3(9)A GENERAL

Prior to driving any piles, the Contractor shall submit to the Engineer for approval, the details of each proposed pile driving system. The pile driving system shall meet the minimum requirements for the various combinations of hammer type and pile type specified in this Section. These requirements are minimums and may need to be increased in order to ensure that the required bearing capacity can be achieved, that minimum tip elevations can be reached, and to prevent pile damage.

The Contractor shall submit a wave equation analysis for pile driving systems required by Contract or for all pile driving systems used to drive piles with required ultimate bearing capacities of 300 tons or greater. The wave equation analysis shall be performed by, and bear the stamp of, a civil engineer licensed under Title 18 RCW in the State of Washington (see Section 1-05.3(12)). The wave equation analysis shall be performed in accordance with the requirements of this Specification Section and the user's manual for the program. The wave equation analysis shall verify that the proposed pile driving system does not produce stresses greater than 90 percent of the yield stress for steel piles, or steel casings for cast-in-place concrete piles. For prestressed concrete piles, the allowable driving stress shall be 3 times the square root of f_c', plus prestress in tension, and $0.85f_c'$ minus prestress in compression. The wave equation shall also verify that the pile driving system does not exceed the refusal criteria at the depth of penetration anticipated for achieving the required ultimate bearing capacity and minimum tip elevation. Furthermore, the wave equation analysis shall verify that at bearing, the maximum driving resistance is 100 blows per foot or less. Unless otherwise specified in the Contract, the following default values shall be used as input to the wave equation analysis program:

Output option (IOUT)	0
Factor of safety applied to (R_{ult})	1.0
Type of damping	Smith
Residual stress option	No
(R_{ult}) is equal to the maximum driving resistance for the pile	

HAMMER EFFICIENCIES		
Hammer	**For Analysis of Driving Resistance**	**For Analysis of Driving Stresses**
Single acting diesel hammers	0.72	0.84
Closed-ended diesel hammers	0.72	0.84
Single acting air/steam hammers	0.60	0.70
Double acting air/steam hammers	0.45	0.53
Hydraulic hammers or other external combustion hammers having ram velocity monitors that may be used to assign an equivalent stroke.	0.85	1.00

Within 15 Working Days after the Engineer receipt of the submittal, the Contractor will be notified of the Engineer's review. If the Contractor wishes to change the pile driving system after the Contractor's proposed system has been approved, the Contractor shall comply with the requirements of Section 1-05.3(5).

6-05.3(9)B PILE DRIVING EQUIPMENT MINIMUM REQUIREMENTS

For each drop hammer used, the Contractor shall weigh it in the Engineer's presence or provide the Engineer with a certificate of its weight. The exact weight shall be stamped on the hammer. Drop hammers shall have a weight of not less than:

1. 3,000 pounds for piles under 50 feet long that have an ultimate bearing capacity of not more than 60 tons; and
2. 4,000 pounds for piles 50 feet and longer or that have an ultimate bearing capacity of 60 to 90 tons.

If a drop hammer is used for timber piles, it is preferable to use a heavy hammer and operate with a short drop.

For each diesel, hydraulic, steam, or air-driven hammer used, the Contractor shall provide the Engineer with the manufacturer's specifications and catalog. These shall show all data needed to calculate the developed energy of the hammer used.

Underwater hammers may be used only with approval of the Engineer.

Drop hammers on timber piles shall have a maximum drop of 10 feet. Drop hammers shall not be used to drive timber piles that have ultimate bearing capacities of more than 60 tons.

When used on timber piles, diesel, hydraulic, steam, or air-driven hammers shall provide at least 13,000 foot-pounds of developed energy per blow. The ram of any diesel hammer shall have a weight of at least 2,700 pounds.

Precast concrete, and precast-prestressed concrete piles shall be driven with a single-acting steam, air, hydraulic, or diesel hammer with a ram weight of at least half as much as the weight of the pile, but never less than the minimums stated in the tables following. The ratio of developed hammer energy to ram weight shall not exceed six. Steel casings for cast-in-place concrete, steel pipe, and steel H-piles shall also be driven with diesel, hydraulic, steam, or air hammers.

These hammers shall provide at least the following developed energy per blow:

Minimum Developed Energy per Blow (ft-lbs)				
Maximum Driving Resistance (tons)	**Air or Steam Hammers**	**Open Ended Diesel Hammers**	**Closed Ended Diesel Hammers**	**Hydraulic Hammers**
Up to 165	21,500	23,000	30,000	18,500
166 to 210	27,500	29,500	38,000	23,500
211 to 300	39,000	41,500	54,000	33,500
301 to 450	59,000	63,000	81,000	50,500

In addition, the ram of any diesel or hydraulic hammer shall have the following minimum weights:

Maximum Driving Resistance (tons)	Minimum Ram Weight (lbs)
Up to 165	2,700
166 to 210	4,000
211 to 300	5,000
301 to 450	6,500

The minimum hammer size requirement may be waived by the Engineer if a wave equation analysis demonstrates the ability of the hammer to obtain the required bearing capacity and minimum tip elevation without damage to the pile.

Vibratory hammers may be used to drive piles provided the location and plumbness requirements of this Section are met. The required bearing capacity for all piles driven with vibratory hammers will be determined according to Section 6-05.3(12) by driving the pile at least an additional 2 feet using an impact hammer. This method of determining bearing capacity will be accepted provided the blows per inch are either constant or increasing. If the pile cannot be driven 2 feet, the pile will be considered acceptable for bearing if the pile is driven to refusal.

If water jets are used, the number of jets and water volume and pressure shall be enough to erode the material next to the pile at the tip. The equipment shall include a minimum of two water jet pipes and two 3/4 -inch jet nozzles. The pump shall produce a constant pressure of at least 100 psi at each nozzle.

6-05.3(9)C PILE DRIVING LEADS

All piles shall be driven with fixed-lead drivers. The leads shall be fixed on the top and bottom during the pile driving operation. Leads shall be long enough to eliminate the need for any follower (except for timber piles as specified in Section 6-05.3(11)E). To avoid bruising or breaking the surface of treated timber piles, the Contractor shall use spuds and chocks as little as possible. In building a trestle or foundation with inclined piles, leads shall be adapted for driving batter piles.

A helmet of the right size for the hammer shall distribute the blow and protect the top of steel pile or steel casing from driving damage. The driving head shall be positioned symmetrically below the hammer's striking parts, so that the impact forces are applied concentric to the pile top.

For piles with specified ultimate bearing capacities of 300 tons or greater, pile driving leads other than those fixed at the top and bottom may be used to complete driving when all of the following criteria are met:

1. Each plumb and battered pile is located and initially driven at least 20 feet in true alignment using fixed leads or other approved means; and
2. The pile driving system (hammer, cushion and pile) shall be analyzed by Pile Driving Analyzer (PDA) to verify that driving stresses in the pile are not increased due to eccentric loading during driving, and transferred hammer energy is not reduced due to eccentric loading during driving, for all test piles and at least one production pile per pier.

The Contractor shall submit the revised fixing of leads set-up and PDA analysis to the Engineer prior to pile driving.

6-05.3(10) TEST PILES

If specified in the Contract, the Contractor shall drive test piles to determine pile lengths satisfying the specified load-carrying capacity, penetration, or both. Test piles shall:

1. Be made of the same material and have the same tip diameter as the permanent piles (although test piles for treated timber piles may be either treated or untreated);
2. Be driven with pile tips if the permanent piles are to have tips;
3. Be prebored when preboring is specified for the permanent piles;
4. Have the same cross-section and other characteristics of the permanent piles for steel casings for cast-in-place concrete, precast concrete, precast-prestressed concrete, or steel pipe or H piles;
5. Long enough to accommodate Project Site soil conditions and Contract requirements;
6. Driven with the same equipment and methods to be used for the permanent piles;
7. Located where the Engineer directs; and
8. Driven before the permanent piles in a given pier.

Test piles may also be driven by the Contractor, at no additional cost to the Owner, as evidence that the pile driving system selected does not damage the pile or result in refusal prior to reaching any specified minimum tip elevation.

Timber test piles shall be driven outside the footing and cut off 1 foot below the finished ground line. Timber test piles shall not be used in place of permanent piles.

Steel test piles and all types of concrete test piles shall become permanent piles. The Engineer has reduced the number of these permanent piles by the number of test piles.

The Contractor shall base test pile length on test-hole data provided in the Contract. Any test pile not long enough to meet Contract requirements shall be replaced (or spliced if the Contract allows splicing) at no additional cost to the Owner.

In foundations and trestles, test piles shall be driven to at least 15 percent more than the bearing capacity required for the permanent piles, except where pile driving criteria is determined by the wave equation. When pile driving criteria is specified to be determined by the wave equation, the test piles shall be driven to the same ultimate bearing capacity as the production piles. Test piles shall penetrate to at least the minimum tip elevation(s) specified in the Contract. If no minimum tip elevation is specified, test piles shall extend at least 10 feet below the bottom of the concrete footing or groundline, and 15 feet below the bottom of the concrete seal.

When any test pile to be left as a permanent pile has been damaged by handling or driving, the Contractor shall remove and replace the pile at no additional cost to the Owner. The Engineer may direct the Contractor to overdrive the test pile to more than 15 percent above the minimum bearing capacity for permanent piles or above ultimate bearing capacity if the wave equation is used to determine driving criteria. In this case, the overdriving shall be at no additional cost to the Owner. But if pile damage results from this overdriving, any removal and replacement will be at the Owner's expense.

6-05.3(11) DRIVING PILES

6-05.3(11)A TOLERANCES

For elevated pier caps, the tops of piles at cut-off elevation shall be within 2 inches of the locations indicated in the Contract. For piles capped below final grade, the tops of piles at cut-off elevation shall be within 6 inches of the horizontal locations indicated in the Contract. No pile edge shall be nearer than 4 inches from the edge of any footing or cap. Piles shall be installed such that the axial alignment of the top 10 feet of the pile is within 4 percent of the specified alignment. No misaligned steel or concrete piles shall be pulled laterally. A properly aligned section shall not be spliced onto a misaligned section for any type of pile. All piles shall be driven vertically unless indicated otherwise on the Drawings.

6-05.3(11)B FOUNDATION PIT PREPARATION

The Contractor shall replace any damaged pile whether before or during driving at no additional cost to the Owner.

The Contractor shall complete all foundation pits (and build any required cofferdams or cribs) before driving foundation piles. The Contractor shall adjust pit depths to allow for upheaval caused by pile-driving. Before constructing the footing or pile cap, the Contractor shall restore the pit bottom to the specified elevation by removing heaved material or by backfilling with granular material specified in the Contract.

6-05.3(11)C PREPARATION FOR DRIVING

Treated and untreated timber piles shall be cut square on the butt ends on-site just before driving. If piles are to be driven into or through hard soils, then caps, collars, or bands shall be placed on the butt ends to prevent crushing or brooming. If the head area of the pile is larger than that of the hammer face, the head shall be snipped or chamfered to fit the hammer. On treated piles, the heads shall be snipped or chamfered to at least the depth of the sapwood to avoid splitting the sapwood from the pile body.

The Contractor shall match timber pile sizes in any single bent to prevent sway braces from undue bending or distorting.

When driven, pile faces shall be turned as shown on the Drawings.

No precast-prestressed pile shall be driven until sample concrete test cylinders taken of the pile concrete pour reach the minimum compressive strength specified in the Contract. On all other precast piles, the concrete test cylinders shall reach a compressive strength of at least 4,000 psi before the piles are driven.

Helmets of approved design shall protect the heads of all precast concrete piles as they are driven. Each helmet shall have fitted into it a cushion next to the pile head. The bottom side of the helmet shall be recessed sufficiently to accommodate the required pile cushion and hold the pile in place during positioning and driving. The inside helmet diameter shall be determined before casting the pile, and the pile head shall be formed to fit loosely inside the helmet.

Steel Casing, steel pipe, or H-piles shall have square-cut ends. During driving, each pile head shall be protected by a fitted metal pile helmet.

6-05.3(11)D ACHIEVING MINIMUM TIP ELEVATION AND BEARING

Once pile driving has started, each pile shall be driven continuously until the required load bearing capacity shown in the Contract has been achieved. Pauses during pile driving, except for splicing, mechanical breakdown, or other unforeseen events, shall not be allowed.

If the Contract specifies a minimum tip elevation, the pile shall be driven to at least the minimum tip elevation, even if the load bearing capacity has been achieved. If a pile does not develop the required load-bearing capacity at the minimum tip elevation, the Contractor shall continue driving the pile until the required bearing capacity is achieved. If no minimum tip elevation is specified, then the piles shall be driven to the load bearing capacity shown in the Contract and the following minimum penetrations:

Pile Application	Pile Tip Minimum Penetration
Pile supporting cross-beams bents	10 feet below final top of ground elevated pile caps elevation
Piles supporting foundations	10 feet below bottom of foundation
Piles with a concrete seal	15 feet below bottom of seal

If overdriving is required in order to reach a specified minimum tip elevation, the Contractor shall provide a pile driving system that does not result in damage to the pile, or produces refusal before the minimum tip elevation is reached.

So long as the pile is not damaged and the embankment or foundation material being driven through is not permanently damaged, the Contractor shall use "normal means" necessary to:

1. Secure the minimum depth specified;
2. Penetrate hard material that lies under a soft upper layer;
3. Penetrate through hard material to obtain the specified minimum tip elevation; or
4. Penetrate through a previously placed embankment.

"Normal means" refer to methods such as preboring, spudding, or jetting. Blasting or drilling through obstructions are not considered "normal means" and shall not be used.

Prebored holes and pile spuds shall have a diameter no larger than the least outside dimension of the pile. After the pile is driven, the Contractor shall fill all open spaces between the pile and the soil caused by the preboring or spudding with dry sand, or pea gravel, or controlled density fill as approved by the Engineer.

If water jets are used, the jets shall be withdrawn before the pile reaches its final penetration, and the pile shall then be driven to its final penetration and bearing capacity. The pile shall be driven a minimum of 2 feet to obtain bearing after the jets are withdrawn, or to refusal, whichever occurs first. If the water jets loosen a pile previously driven, it shall be redriven in place or pulled and replaced by a new pile. To check on pile loosening, the Contractor shall attempt to redrive at least one in every five piles as selected by the Engineer.

If the Engineer requires, the Contractor shall overdrive the pile beyond the minimum load-bearing capacity and minimum tip elevation shown in the Contract. In this case, the Contractor will not be required to:

1) Use other than "normal means" to achieve the additional penetration;
2) Bear the expense of removing or replacing any pile damaged by overdriving; or
3) Bear the expense of overdriving the pile more than 3 feet as specified in Section 6-05.5.

In driving piles for footings with seals, the Contractor shall use no method (such as jetting or preboring) that might reduce friction capacity.

6-05.3(11)E USE OF FOLLOWERS FOR DRIVING

Followers shall not be used to drive concrete or steel piles. On timber piles, the Contractor may use steel followers if the driving head and cap fit snugly over the pile head. Wood followers will not be allowed. The Engineer prefers, however, that the hammer strike the pile head directly without any cushion, block, or follower. If a follower is used, the Contractor shall, in every group of 10 piles, drive one long pile without a follower to the required bearing capacity and minimum tip elevation. This long pile shall be used to test the bearing capacity of the piles driven with a follower in the group. The tip elevation of the long pile shall be similar to the tip elevations of the piles driven with the follower. If the tip elevations vary considerably, the Contractor shall redrive the remaining piles in the group to the tip elevation of the longer pile.

6-05.3(11)F PILE DAMAGE

The Contractor shall remove and replace any pile which is damaged at no additional cost to the Owner.

After driving a steel casing for a cast-in-place concrete pile, the Contractor shall leave it empty until the Engineer has inspected and accepted it. The Contractor shall make available to the Engineer a light suitable for inspecting the entire length of its interior. The Engineer will reject any casing that is improperly driven, that shows partial collapse that would reduce its bearing capacity, that has been reduced in diameter, or that does not keep out water. The Contractor shall remove and replace any rejected casing at no additional cost to the Owner.

Pile heads which have been broomed, rolled, or otherwise damaged shall be cut back to undamaged material before proceeding with driving or acceptance of the pile.

6-05.3(11)G PILE CUTOFF

The Contractor shall trim the tops of all piles to the true plane and to the elevation indicated in the Contract. If a pile is driven below cutoff elevation without the Engineer's approval, the Contractor shall remove and replace the pile at no additional cost to the Owner even if this requires a longer pile. Any pile that rises as nearby piles are driven, shall be driven down again.

Any piles under timber caps or grillages shall be sawed to the exact plane of the structure above them and fit it exactly. No shimming on top of timber piles to adjust for inaccurate pile top elevations will be permitted. If a timber pile is driven out of line, it shall be straightened without damage before it is cut off or braced.

Steel casings shall be cut off at least 6 inches below the finished ground line or at the low water line if a casing may be visible.

6-05.3(11)H PILE DRIVING FROM OR NEAR ADJACENT STRUCTURES

The Contractor shall not drive piles from an existing structure unless all of the following conditions are met:

1. The existing structure is to be demolished within the Contract;
2. The existing structure is permanently closed to traffic; and
3. Working Shop Drawings are submitted in accordance with Sections 6-01.9 and 6-02.3(16), showing the structural adequacy of the existing structure to safely support all of the construction loads.

To minimize the detrimental effects of pile driving vibrations on new concrete less than 28 days old, piles shall not be driven closer to the new concrete than the distance determined by the following formula:

D = C times the square root of E

Where: D = distance in feet
E = rated hammer energy in foot-pounds
C = coefficient shown in the following table based on the number of days of curing time

Curing Time (days)	Coefficient (C)	Curing Time (days)	Coefficient (C)
1	0.34	6	0.12
2	0.23	7-9	0.11
3	0.18	10-13	0.10
4	0.15	14-20	0.09
5	0.13	21-28	0.08

This distance may be reduced if approved in writing by the Engineer.

6-05.3(12) DETERMINATION OF BEARING VALUES

The following formula shall be used to determine ultimate bearing capacities:

$P = F \times E \times L_n(10N)$

Where:

P = ultimate bearing capacity, in tons
F = 1.65 for air/steam hammers
= 1.55 for open ended diesel hammers
= 1.2 for close ended diesel hammers
= 1.9 for hydraulic hammers
= 0.6 for drop hammers

E = developed energy, equal to W times H[1], in ft-kips
W = weight of ram, in kips
H = vertical drop of hammer or stroke of ram, in feet
N = average penetration resistance in blows per inch for the last 4 inches of driving
L_n = the natural logarithm, in base "e"

[1]For closed-end diesel hammers (double-acting), the developed hammer energy (E) is to be determined from the bounce chamber reading. Hammer manufacturer calibration data may be used to correlate bounce chamber pressure to developed hammer energy. For double acting hammer hydraulic and air/steam hammers, the developed hammer energy shall be calculated from ram impact velocity measurements or other means approved by the Engineer. For open ended diesel hammers (single-acting), use the blows per minute to determine the developed energy (E).

The above formula applies only when:

1. The hammer is in good working condition and operating in a manner within the manufacturer's recommendations;
2. A follower is not used;
3. The pile top is not damaged;
4. The pile top is free from broomed or crushed wood fiber;
5. The penetration occurs at a reasonably quick, uniform rate; and the pile has been driven at least 2 feet after any interruption in driving greater than 1 hour in length;
6. There is no perceptible bounce after the blow. If a significant bounce cannot be avoided, twice the height of the bounce shall be deducted from "H" to determine its true value in the formula;
7. For timber piles, bearing capacities calculated by the formula above shall be considered effective only when it is less than the crushing strength of the piles; and
8. If "N" is greater than or equal to 1.0 blow/inch.

If "N" required to achieve the required ultimate bearing capacity using the above formula is less than 1.0 blow/inch, the pile shall be driven until the penetration resistance is a minimum of 1.0 blow/inch for the last 2 feet of driving.

The Engineer may require the Contractor to install a pressure gauge on the inboard end of the hose to monitor pressure at the hammer.

If water jets are used in driving, bearing capacities shall be determined either: (1) by calculating it with the driving data and the formula in this Section after the jets have been withdrawn and the pile is driven at least 2 feet, or (2) by applying a test load.

6-05.3(13) TREATMENT OF TIMBER PILE HEADS

After cutting timber piles to correct elevation, the Contractor shall thoroughly coat the heads of all untreated piles with two coats of an approved preservative that meets the requirements of Section 9-09 (except concrete-encased piles).

After cutting treated timber piles to correct elevation, the Contractor shall brush three coats of an approved preservative that meets the requirements of Section 9-09 on all pile heads (except those to be covered with concrete footings or concrete caps). The pile heads shall then be capped with alternate layers of an approved roofing asphalt and a waterproofing fabric that conforms to Section 9-11.2. The cap shall be made of four layers of an approved roofing asphalt and three layers of fabric. The fabric shall be a single piece cut large enough to cover the pile top and fold down at least 6 inches along all sides of the pile. After the fabric cover is bent down over the pile, its edges shall be fastened with large-head galvanized nails or with three turns of galvanized wire. The edges of the cover shall be neatly trimmed.

On any treated timber pile encased in concrete, the cut end shall receive two coats of an approved preservative that meets the requirements of Section 9-09 and then a heavy coat of an approved roofing asphalt.

6-05.3(14) EXTENSIONS AND BUILD-UPS OF PRECAST CONCRETE PILES

The Contractor shall add extensions, or build-ups (if necessary) on precast concrete piles after they are driven to the required bearing capacity and minimum tip elevation.

Before adding extensions or build-ups to precast-prestressed piles, the Contractor shall remove any spalled concrete, leaving the pile fresh-headed and with a top surface perpendicular to the axis of the pile. The concrete in the build-up shall reach a minimum compressive strength of 5,000 psi at 28 days.

Before adding to a non-prestressed precast concrete pile, the Contractor shall cut the pile head to a depth 40 times the diameter of the vertical reinforcing bar. The final cut shall be perpendicular to the axis of the pile. Reinforcement of the same density and configuration as used in the pile shall be used in the build-up and shall be fastened firmly to the projecting steel. Forms shall be placed to prevent concrete from leaking along the pile. The concrete in the build-up shall reach a minimum compressive strength of 4,000 psi at 28 days.

Just before placing the concrete for extensions or build-ups to precast or precast-prestressed concrete piles, the Contractor shall thoroughly wet the top of the pile. Forms shall remain in place at least three days.

6-05.3(15) COMPLETION OF CAST-IN-PLACE CONCRETE PILES

After acceptance of the casing by the Engineer (see Section 6-05.3(11)F), the driven casing shall be cut off horizontally at the required elevation. They shall be clean and free of water when concrete and reinforcing steel are placed.

These piles shall consist of steel casings driven into the ground, reinforced as specified, and filled with designation P concrete.

6-05.3(15)A REINFORCEMENT

All reinforcing bars shall be fastened rigidly into a single unit, then lowered into the casing before the concrete is placed. Loose bars shall not be used.

Spiral hooping reinforcement shall be deformed steel bar, plain steel bar, cold-drawn wire, or deformed wire.

6-05.3(15)B PLACING CONCRETE

The Contractor shall remove all debris and water from the casing before placing concrete. If the casing cannot be dewatered, the casing shall be removed (or cut off 2 feet below the ground surface and filled with sand) and a new casing shall be driven at a location determined by the Engineer.

The Contractor shall place concrete continuously through a rigid conduit at least 5 feet long. The concrete shall be directed down the center of the pile casing completely filling the casing including around the reinforcement. The top 5 feet of concrete shall be placed with the tip of the conduit below the top of fresh concrete. The Contractor shall vibrate, as a minimum, the top 10 feet of concrete. In all cases, the concrete shall be vibrated to a point at least 5 feet below the original ground line.

6-05.4 MEASUREMENT

Bid items of work completed pursuant to the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs herein this Section.

Measurement for driving (type) pile will be the number of piles driven in place.

In these categories, measurement will be the number of linear feet driven below pile cutoff:

1. Furnishing timber piles (untreated or name of treatment).
2. Precast concrete and precast-prestressed concrete piles.
3. Cast-in-place concrete piles.
4. Furnishing steel piles.

Measurement for furnishing and driving test piles will be the number actually furnished and driven as the Contract requires.

Measurement for steel pile tips or shoes will be by the number of tips or shoes actually installed and driven in place on steel casings or steel piles.

6-05.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-05 will be made at the Bid item prices Bid for Bid items listed or referenced as follows:

1. "**Furnishing and Driving (Type) Test Pile**", per each.

The Bid item price for "Furnishing and Driving (Type) Test Pile" shall include all costs for the work required for furnishing and driving test piles to the bearing capacity or penetration required by the Engineer, furnishing and installing a pile tip when pile tips are specified for the permanent piles, preboring when preboring is specified for the permanent piles, for pulling the piles or cutting them off as required, and for removing them from the site or for delivery to the Owner for salvage when ordered by the Engineer. This Bid item price shall also include all costs in connection with moving all pile driving equipment or other necessary equipment to the Project Site and for removing all such equipment from the Project Site after the piles have been driven. If, after the test piles have been driven, it is found necessary to eliminate the pile from all or any part of the Structure, moving the pile driving equipment to and from the site of this work shall be at no additional cost to the Owner.

2. "**Driving Timber Pile (untreated or name treatment)**", per each.

The Bid item price for "Driving Timber Pile (untreated or name treatment)" shall include all costs for the work required to drive the specified timber pile including any metal shoes which the Contractor has determined to be beneficial to the pile driving.

3. "**Driving Concrete Pile (Size)**", per each.
4. "**Driving Steel Pile**", per each.

The Bid item prices for "Driving Concrete Pile (Size)" and for "Driving Steel Pile" shall include all costs for the work required to drive the pile to the bearing and/or penetration specified. When overdriving piles beyond the minimum bearing capacity and/or minimum tip elevation specified in the Contract is required by the Engineer, payment for the first 3 feet of overdriving shall be included in the Bid item prices for "Driving Concrete Pile (Size)" and for "Driving Steel Pile". Additional penetration beyond the first 3 feet of overdriving will be paid for in accordance with Section 1-09.4.

5. "**Furnishing Timber Piles, (Untreated or Name Treatment)**", per linear foot.
6. "**Furnishing Concrete Piles, (Size)**", per linear foot.
7. "**Furnishing Steel Piles**", per linear foot.

The Bid item prices for "Furnishing Timber Piles, (Untreated or Name Treatment)", for "Furnishing Concrete Piles, (Size)", and for "Furnishing Steel Piles" shall include all costs for the work required to furnish and store the piles specified and shall include extra pile length ordered but not driven.

8. "**Precast Concrete Pile Buildup**", per each.

Payment for build-ups of precast or precast-prestressed concrete piles will be made in accordance with Section 1-09.4. No payment will be made for build-ups or additional lengths of build-up made necessary because of damage to the pile during driving. The length of splice for precast concrete piles includes the length cut off to expose reinforcing steel for the splice. The length of splice for precast-prestressed piles includes the length in which holes are drilled and reinforcing bars are grouted.

9. "**Furnishing Steel Pile Tip or Shoe (Size)**", per each.

The Bid item price for "Furnishing Steel Pile Tip or Shoe (Size)" shall include all costs for the work required to furnish and install the pile tip or shoe. Payment for pile tip or shoe for test piles or test piles which are incorporated as permanent piles shall be included in the Bid item "Furnishing and Driving (Type) Test Pile" and no separate or additional payment will be made.

10. **Other payment information.**

Payment for build-ups of precast or precast-prestressed concrete piles will be made in accordance with Section 1-09.4. No payment will be made for build-ups or additional lengths of build-up made necessary because of damage to the pile during driving. The length of splice for precast concrete piles includes the length cut off to expose reinforcing steel for the splice. The length of splice for precast-prestressed piles includes the length in which holes are drilled and reinforcing bars are grouted.

Any pile which is damaged or destroyed before or at the time it is being driven shall be replaced by the Contractor at no additional cost to the Owner.

The various Bid item prices for driving piles shall cover all costs related to the use of water jets, preboring, or spudding. All costs the Contractor incurs in redriving piles loosened as a result of water jets, preboring, or spudding shall be at no additional cost to the Owner.

The Bid item price for furnishing concrete pile (size specified) shall cover all costs related to the pile build-up above the steel casing.

All costs to remove and replace test piles intended to remain as permanent piles but which were damaged in handling or driving shall be at no additional cost to the Owner.

All costs to remove and replace any pile damaged in driving or straightening or driven below grade shall be at no additional cost to the Owner.

Should it be determined by survey that the elevations of the pile tops have heaved after installation, the Contractor shall redrive the heaved piles to a pile tip penetration equal to or greater than that achieved during initial driving of the heaved pile at no additional cost to the Owner.

All pile cutoffs and damaged pile shall become the property of the Contractor and shall be disposed of by the Contractor.

The Engineer will inspect all piles prior to driving and reserves the right to have any pile which is damaged or destroyed before or at the time it is being driven replaced by the Contractor at no additional cost to the Owner.

The Contractor shall furnish the necessary lengths of pile to reach from cutoff elevation up to the position of the driving equipment at no additional cost to the Owner.

All cost and expense to perform the work of removing the heaved soil within the limits of the footing excavation and filling the voids remaining from extracted piles with sand and pea gravel shall be considered incidental to the construction and shall be included in the Bid item prices for the various Bid items of Work involved in the project at no additional cost to the Owner.

All cost and expense for design of pile including uplift and pile build-ups, and pile markings for blow count shall be considered incidental to the pile Bid items and shall be at no additional cost to the Owner.

All cost for submittals shall be as specified in Section 1-05.3.

Payment for "Steel Reinforcing Bar" shall be in accordance with Section 6-02.5.

All cost and expense for jetting, sand and pea gravel, and vibration monitoring shall be considered incidental to the Bid item price for the pile Bid item and shall be at no additional cost to the Owner.

Unless otherwise specified in the Contract, the cost of PDA testing per Section 6-05.3(9)C shall be included in the various Bid item prices for driving piles and shall be at no additional cost to the Owner.

The cost of overdriving per Section 6-05.3(11)D shall be incidental to the various Bid item prices for furnishing and driving piles and shall be at no additional cost to the Owner.

SECTION 6-06 BRIDGE AND PEDESTRIAN RAILINGS

6-06.1 DESCRIPTION

Section 6-06 addresses the work of providing and building bridge railings and pedestrian railings that meet the requirements of the Contract.

6-06.2 MATERIALS

Material shall meet the requirements of the following Sections:

Timber Railing	9-09
Metal Railing	9-06.18

6-06.3 CONSTRUCTION REQUIREMENTS

6-06.3(1) TIMBER WHEEL GUARDS AND RAILINGS

Timber wheel guards and timber railings shall be true to line and grade and framed accurately. Construction methods not specified in this Specification Section shall follow the construction requirements of Section 6-04.

Unless the Contract indicates otherwise, wheel guards shall be:

1. Beveled and surfaced on the roadway side and surfaced on the top edge. They may be surfaced on four sides (S4S);
2. Laid in sections at least 12 feet long; and
3. Bolted through the floor plank and outside stringer (or nailing piece) with 3/4 inch diameter bolts spaced no more than 4 feet apart.

All rails and rail post material shall be S4S and painted as required in Sections 6-04 and 6-07. Railing members shall be fastened securely together, with the bolts tightened once at installation, and again just before the Physical Completion Date. The Contractor shall provide the Engineer at least 3 Working Days advance notice of the last tightening.

6-06.3(2) METAL RAILINGS

Metal railing includes posts, web members, and horizontal members of the sidewalk and roadway railing. Unless the Contract indicates otherwise, railings shall be made of aluminum alloy or steel.

Before fabricating the railing, the Contractor shall submit Shop Drawings for the Engineer's review as specified in Section 1-05.3. The Contractor may substitute other rail connection details for those shown on the Drawings if details of these changes are shown and noted in the Shop Drawings and if the Engineer approves (Section 1-05.3(5)). Anchor bolts or wedge anchors shall be positioned with a template to ensure that bolts match the hole spacings of the bottom channels or anchorage plates.

Where specified, cover plates shall fit the bottom channel tightly after being snapped into position.

Metal railings shall be installed true to line and grade (or camber). After first setting the railing, the Contractor shall readjust all or part of it, if necessary, to create an overall line and grade as indicated on the Drawings.

6-06.4 MEASUREMENT

Bid items of work completed pursuant to the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs herein this Section.

Timber railing will be measured by the linear foot along the line and slope at the base of the completed railing.
Metal railing will be measured by the linear foot along the line and slope at the base of the completed railing.

6-06.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-06 will be made at the Bid item prices Bid only for the Bid items listed or referenced as follows:

1. "**Bridge Railing, (Type)**", per linear foot.
2. "**Metal Railing, (Type)**", per linear foot.

The Bid item prices for "Bridge Railing, (Type)" and for "Metal Railing, (Type)" shall include all costs for the work required to construct the railings as shown on the Drawings and as specified in this Section, including longitudinal, vertical and inclined structural members, plates, fastenings, anchor bolts, galvanizing, grouting, and painting as specified. In case no Bid item is included in the Bid Form for "Bridge Railing, (Type)" and "Metal Railing, (Type)" and payment is not otherwise provided, all metal railings shall be included in the Bid item price for the Bid item "Structural Carbon Steel" as specified in Section 6-03.

3. "**Timber Railing, (Type)**", per linear foot.

The Bid item price for "Timber Railing, (Type)" shall include all costs for the work required to construct, provide hardware, and paint the complete railings and posts as shown on the Drawings.

SECTION 6-07 PAINTING

6-07.1 DESCRIPTION

Section 6-07 addresses the work of preparing the surface, providing and applying the paint, and cleaning up. This work shall comply with all requirements of the Contract.

6-07.2 MATERIALS

Materials shall comply with the requirements in Section 9-08.

6-07.3 CONSTRUCTION REQUIREMENTS

6-07.3(1) PAINTING NEW STEEL STRUCTURES

6-07.3(1)A GENERAL

Shop painting of structural steel shall comply with Section 6-03.3(30). No new structural steel shall be painted until inspected by the Engineer.

6-07.3(1)B NUMBER OF COATS AND COLOR

All new structural steel work shall be cleaned and painted with three coats of paint, except where specified otherwise in the Contract. Cleaning shall conform to the requirements set forth in 6-07.3(1)F. The first coat shall be applied immediately after sandblasting the steel in accordance with the applicable parts of Section 6-03.3(30). The second and third coats shall be applied after erection except as otherwise specified in Section 6-03.3(41). The color of each succeeding coat shall be sufficiently different from that previously applied to readily permit the discovery of an incomplete application of the paint coat. The color of the third coat shall be as specified in the Contract. Three color samples, approximately 10 inches by 10 inches of the final coat shall be submitted to the Engineer.

6-07.3(1)C WEATHER CONDITIONS

Unless the manufacturer's instructions state otherwise and the Engineer approves, paint shall not be applied when:

1. The air and metal are cooler than 40°F;
2. Metal surfaces are damp or the air is misty or the surface temperature is less than 5°F above the dew point;
3. The Engineer believes conditions are unsuitable; or
4. The metal is hot enough to cause the paint to blister and leave a porous finish.

Steel painted under cover in damp or cold weather shall remain under cover until the paint dries or weather conditions permit open exposure.

6-07.3(1)D APPLICATION

Painters shall be competent and do careful work. All field applied coats shall be brushed on unless the Contract specifies otherwise. All paints shall be applied in compliance with manufacturer’s recommendations, unless noted otherwise in the Contract.

Painters shall use round or oval shaped brushes, but with aluminum paint, may use flat brushes up to 4 inches wide. Brushing shall first be in a series of tight circles to fill surface roughness, and then in parallel strokes to leave a smooth, even coating that adheres closely to the metal or previous coat. On surfaces that cannot be brushed, painters shall use sheepskin or other daubers approved by the Engineer.

Prior to the application of 1st coat primer, 2nd coat primer, or final coat, the Contractor shall obtain approval from the Engineer who will verify that the surfaces to be painted during that day have first been cleaned in accordance with these Specifications, unless the Contract specifies otherwise.

Bolts, the edges of plates, angles, and other rolled shapes shall receive an extra heavy coating. Painters shall work the paint well into all joints and crevices. Unless the manufacturer's instructions state otherwise and the Engineer approves, all areas named in this paragraph shall be painted lightly just before general painting. This light coating shall be recoated when the general coat is applied.

The Contractor shall schedule operations so that all sand blasted surfaces are primed before the end of the Working Day. Any blasted surface not primed before the end of the Working Day shall be reblasted and primed. If the air temperature or the temperature of the steel falls below the dewpoint after cleaning and prior to application of the first Primer Coat, the Contractor shall reclean the affected area(s) to a condition acceptable to the Engineer at no additional cost to the Owner.

When A-6 (Zinc Dust Zinc Oxide Primer) is used as a primer, the Contractor shall insure that the zinc solids are continually mixed in solution. The Contractor shall mix only the amount of A-6 that can be used up within the current Working Day. Any remaining A-6 primer shall be discarded at the end of the day.

Unless the manufacturer's instructions state otherwise and the Engineer approves, the Contractor shall allow each field coat of paint to cure for a minimum of 18 hours, prior to the application of the succeeding coat of paint. Each succeeding field coat of paint shall be applied within 72 hours after the application of the previous coat of paint.

Should a painted area indicate bond failure, become soiled, contaminated, or rusted prior to the application of any subsequent coats, the Contractor shall reclean and repaint the area at no additional cost to the Owner.

See Section 1-07.5 regarding the prevention of environmental pollution and the preservation of public natural resources including as applicable, permit requirements and other requirements in the Contract.

Any structural defects, including cracks, missing bolts or rivets, deterioration, etc., detected during the painting of these structures shall be promptly brought to the attention of the Engineer.

If the Contract permits spray painting, airless spray machines shall apply paint as these Specifications require unless the manufacturer recommends otherwise and the Engineer approves. All sprayed paint shall be brushed as described elsewhere in the Section. The Contractor shall not, in attempting to operate a sprayer, add more thinner or other substances than the formulas permit. Before airless spray painting, the Contractor shall demonstrate the airless sprayer application to a test area selected by the Engineer. If the airless sprayer does not produce acceptable results, the Engineer may prohibit its use and require brushing instead.

Before it is removed from its containers, paint shall be stirred thoroughly by a mechanical mixer or by other means. During application, it shall be stirred often enough to keep pigments in suspension.

Paint shall be shipped from the factory at brushing consistency. In no case shall thinner, other than minor amounts needed for cleanup, be used on the project. Any thinner used for cleanup shall be used and stored off the bridge structure.

The final coat on any surface exposed to view shall be made with paint from a common batch. The Contractor shall provide the Engineer with a Manufacturer Certificate of Compliance stating that the final coat is, in fact, from a common batch including material invoices and lot numbers.

6-07.3(1)E REMOVAL OF UNACCEPTABLE PAINT

The Contractor shall remove and replace any paint that has the wrong color, is of improper consistency or purity, or that is applied on metal not cleaned according to Specifications at no additional cost to the Owner.

6-07.3(1)F FIELD CLEANING

After completing erection work (including bolting, straightening bent material, etc.), the Contractor shall thoroughly clean all metal surfaces to an acceptable condition, using metal brushes, scrapers, chisels, hammers, sandblasting or other means the Engineer requires to remove rust, scale, and dirt. Solvents may be used to remove oil and grease, and bristle or wood fiber brushes to remove loose dust. If the structure is covered with dirt or concrete residue, pressure flushing may be required (as specified in Section 6-07.3(2)).

When shipping, handling, or welding injures the shop coat, damaged areas shall be thoroughly cleaned by wire brushing before field painting. Between coats of paint, if the Engineer requires, the Contractor shall reclean the structure by the methods described above.

6-07.3(1)G FIELD PAINTING

Immediately after the Engineer approves the field deaning, the Contractor shall apply one touch-up coat of the same paint used for the shop coat to these areas: bolt heads, areas where the shop coat has been broken, and all marks made during shipping or erection.

The first field coat shall be applied only after the touch-up coat is completely dry. If the first field coat leaves small cracks and cavities that are not watertight, they shall be filled with single component urethane sealant meeting the requirements of Federal Specification TT-S-00230C, Type II, Class A (applied per manufacturer’s recommendation) before the second field coat is applied. No later coat shall be applied until the full thickness of the previous coat has dried.

6-07.3(2) REPAINTING EXISTING STEEL STRUCTURES

Unless otherwise specified in the Contract, maintenance painting includes cleaning and painting the metal parts of an existing bridge. Cleaning means removing rust, scale, dead paint, dirt, grease, and other foreign matter. Foreign matter firmly encapsulated in the existing paint, need not be removed. The Contractor shall clean and paint all exposed metal surfaces that may rust. These include all metal surfaces that do not touch other metal, wooden floor or truss members, concrete or stone masonry, or other surfaces.

Pressure flushing shall precede all other methods of cleaning the metal surfaces. Flushing may be omitted in some areas as approved by the Engineer.

Prior to pressure flushing and abrasive blasting, the Contractor shall submit for approval by the Engineer a written procedure for collection and removal of debris and blasting material.

Pressure flushing shall be done with clean, fresh water. The nozzle shall have sufficient pressure to remove all soilage debris, loose paint and loose rust scale from all metal surfaces. The pressure flushing equipment shall produce at least 3,000 psi at the nozzle and a discharge of at least 4 gpm. The nozzle shall have a 25-degree tip and shall be held no more than 9 inches from the surface being washed.

Rust removal shall be by means of abrasive blasting in accordance with SSPC-SP6 specifications. All rust spots that are abrasive blasted shall be blasted to a uniform white metal appearance with no areas of stain and gray mill scale permitted. There shall be no evidence of red or yellow rust at the edges of the blasted area. The blasted area shall be extended to sound paint, and the sound paint edges shall be feathered to give a smooth surface. Minimum sandblasting nozzle pressure shall be 90 psi.

White metal is defined by the Structural Steel Painting Council No. Sa3 as a surface with gray-white metallic color, slightly rough, to form a suitable base for paint. If the old paint at the edge of an abrasive blasted area lifts after the spot coats are applied, the lifted paint shall be scraped off and the damaged areas repainted. Rust spots which cannot be removed effectively by abrasive blasting shall be removed with power brushing, scraping or other effective means.

All corroded areas shall be sweep-blasted 4 to 6 inches beyond the corroded area during spot blasting procedures. Non-galvanized railing shall be 100% sandblasted to Commercial Blast (SSPC-SP6) specifications.

Abrasive blasting operations shall be done in such a manner that no damage occurs to any portions of the work whether partially or entirely completed.

After abrasive blasting, all loose rust, dirt, sand and dust shall be thoroughly removed before paint is applied. Abrasive blasting clean-up and painting shall comply with the pollution prevention requirements of Section 1-07 and any additional requirements specified in the Contract.

A period of three days shall elapse before applying paint to a surface which has been cleaned by flushing, taking care before painting to remove any dust or dirt which may have settled on the steel members in the intervening time. In those areas where flushing cannot be safely accomplished, the surfaces shall be cleaned to an acceptable condition with an approved solvent.

Painting shall not begin until after approval of surface preparation of each section of the structure by the Engineer.

After the touch-up paint has dried, all cracks and cavities which are not sealed with the spot coats, and all cracks and cavities throughout the bridge structure which border upon rusted or stained areas, shall be sealed with single component urethane sealant meeting the requirements of Federal specification TT-S-00230C, Type 2, Class A (applied per manufacturer’s recommendations) before the first coat is applied.

The first coat of paint shall conform to Formula A-6 (Zinc Dust Zinc Oxide Primer) and shall be applied immediately after the steel has been cleaned by sandblasting. The second coat shall also conform to Formula A6 (Zinc Dust Zinc Oxide Primer). The third coat shall conform to Formula C-9-86 (Phenolic Finish coat for Steel). The color of each succeeding coat shall be sufficiently different from that previously applied to readily permit the discovery of an incomplete application of the paint coat. The color of the third coat shall be as specified in the Contract. Three color samples, approximately 10 inches by 10 inches, of the final coat shall be submitted to the Engineer.

If an existing coated surface must be color matched, color samples of the paint manufacturer's product, in the number of shades indicated in the Contract, shall be submitted for the Engineer's approval.

The cleaning-painting requirements of Sections 6-07.3(1)C, 6-07.3(1)D, and 6-07.3(1)E shall apply here unless the Contract specifies otherwise. The Contract typically specifies the number of coats required. If no number is given, the clean metal shall be painted with 3 coats.

If roadway or sidewalk planks lie so close to the metal that they prevent proper cleaning and painting, the Contractor shall remove or cut the planks to provide at least a 1-inch clearance. Any plank removal or cutting shall be done as approved by the Engineer. The Contractor shall replace all planks after painting. If removal breaks or damages the planks and makes them unfit for reuse, the Contractor shall replace them at no additional cost to the Owner.

6-07.3(3) PAINTING TIMBER STRUCTURES

6-07.3(3)A NUMBER OF COATS AND COLOR

Unless the Contract specifies otherwise:

1. Rails and rail posts on timber bridges shall receive 2 coats (with the wheel guard painted only on its top edge and roadway side).
2. Other timber work shall receive 3 coats if the Contract requires other timber work to be painted.

Paint color shall be as indicated in the Contract.

6-07.3(3)B APPLICATION

All wood surfaces which are to be painted shall be prepared in accordance with the paint manufacturer's recommendations and be thoroughly dry and free from oil and dirt. Paint shall be applied by brush, spread evenly, and worked thoroughly into all seasoning cracks, corners, and recesses. No later coat shall be applied until the full thickness of the previous coat has dried.

Final brush strokes with aluminum paint shall be made in the same direction to ensure that powder particles "leaf" evenly.

If a painted surface has been stained by creosote, it shall be given one or more coats of an approved shellac before repainting.

6-07.3(3)C PAINTING TREATED TIMBER

Timber treated with creosote or oil-borne, pentachlorophenol preservatives shall normally not be painted.

Timber treated with water-borne preservatives shall be clean and be reduced to no more than 18 percent moisture content before it is painted. Any visible salt crystals on the wood surface shall be washed and brushed away with the moisture content reduced again to the specified level before painting. Stored timber awaiting painting shall be covered and stacked with spreaders to ensure air circulation.

6-07.3(4) PAINTING GALVANIZED SURFACES

All galvanized surfaces to be painted shall be prepared and painted as follows:

1. Clean all surfaces thoroughly with toluene base solvent;
2. Wipe off the solvent with clean rags until surface is dry; and
3. The clean and dry surface shall be painted according to the following schedule:

First Coat	A-6-86	Zinc Dust Zinc Oxide Primer.
Second Coat	C-9-90	Phenolic Finish Coat for Steel.
Third Coat	C-9-90	Phenolic Finish Coat for Steel.

The color of the finish field coat shall be as specified in the Contract.

Each coat shall be dry before the next coat is applied. All coats applied in the shop *shall* be dried hard before shipment.

The second and third coats shall be applied after field erection and shall conform to Formula C-9-90 (Phenolic Finish Coat for Steel). The color of each succeeding coat shall be sufficiently different from that previously applied to readily permit the discovery of an incomplete application of the paint coat.

If an existing coated surface must be color matched, color samples of the paint manufacturer's product, in the number of shades the Contract requires, shall be submitted for the Engineer's approval. After the color has been selected by the Engineer, three color samples, approximately 10 inches by 10 inches of the selected color shall be submitted to the Engineer.

6-07.3(5) PAINT FILM THICKNESS

A full, wet coat of Formula A-5-61 free from runs and sags produces the proper film thickness (the rapid solvent release in this vinyl pretreatment makes it difficult to measure wet film thickness). Dry film thickness shall be between 0.4 and 0.7 mils.

Any other finish, no matter how it is being applied, shall have a wet thickness of at least 3.0 mils per coat and a dry film thickness of at least 1.5 mils per coat.

If the specified number of coats do not produce a combined dry film thickness of at least the sum of the thicknesses required per coat, the Contractor shall apply another full coat of finish paint.

Film thickness, both wet and dry, shall be measured by suitable gages. Wet measurements shall be taken immediately after the paint is applied, and dry measurements after the coat is dry and hard.

6-07.3(6) PROTECTION OF PUBLIC AND PRIVATE PROPERTY

See Section 1-07 for General Requirements for protecting public and private property, protecting the traffic, protecting the environment, and other legal responsibilities. At the pre-construction conference (Section 1-08.1(2)), or at least 10 Working Days prior to start of painting, the Contractor shall submit a written detailed method for all work related to the painting process as indicated in the Contract. This method shall also indicate a supervisory employee of the Contractor who shall be directly involved in the performance of this work.

The Contractor is required to post signs approved by the Engineer for boaters and traffic regarding the cleaning and painting operations. These signs shall also include information regarding accident spills.

6-07.3(7) MOISTURE CURED URETHANE PAINT

The Contractor shall submit the manufacturer’s recommendations for preparation, prime coat(s) and finish coat(s) application methods, curing times, and other information as necessary to ensure material and workmanship acceptable to the Engineer.

6-07.4 MEASUREMENT

Bid items of work completed pursuant to the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs herein this Section.

6-07.5 PAYMENT

The Bid Form contains no separate payment item for painting because Bid item prices cover all costs related to painting new steel or timber structures. Costs related to painting include preparing the surface; applying the paint; protecting and drying the coatings; protecting pedestrians, vehicles, and public and private property from paint; and supplying all tools, tackles, scaffolding, labor, and materials needed to complete the work.

When required, repainting existing steel bridge will be specified in the Contract.

SECTION 6-08 WATERPROOFING

6-08.1 DESCRIPTION

Section 6-08 addresses the work of applying waterproofing materials to Portland cement concrete surfaces as required by the Contract.

6-08.2 MATERIALS

Materials shall meet the requirements of the following sections:

Asphalt for Waterproofing	9-11.1
Waterproofing Fabric	9-11.2
Portland Cement Mortar	9-11.3

6-08.3 CONSTRUCTION REQUIREMENTS

6-08.3(1) STORAGE OF FABRIC

The fabric shall be stored in a dry, protected place. Rolls shall not be stored standing on end.

6-08.3(2) PREPARATION OF SURFACE

Preparation of surfaces shall be in accordance with the manufacturer's recommendations. Concrete surfaces shall be reasonably smooth and without projections or holes that might puncture the waterproofing membrane. The surfaces shall be dry, with all dust and loose material removed. The Contractor shall not apply waterproofing in wet weather or when the air temperature is below 35°F unless the Engineer approves in writing.

6-08.3(3) APPLICATION OF WATERPROOFING

Unless the manufacturer's instructions state otherwise, waterproofing asphalt shall be stirred frequently as it is heated to between 300°F and 350°F. Each heating kettle shall have a thermometer.

Each coat of primer or asphalt shall begin at the low point of the surface so that water runs over (not against or along) the laps.

In applying the waterproofing, the Contractor shall:

1. Apply a coat of primer and let it dry before applying the first asphalt coat;
2. Mop hot asphalt on a band about 20 inches wide across the full length of the surface;
3. Immediately roll a starter strip of half-width fabric into the asphalt, pressing it into place to rid it of all air bubbles and to conform it closely to the surface;
4. Mop hot asphalt over the starter strip and an adjacent section of surface so that the fresh asphalt forms a band slightly wider than the full width of the fabric;
5. Immediately roll a full-width strip of fabric into the fresh asphalt, pressing it into place as before;
6. Mop hot asphalt on the latest strip and on an adjacent band of the surface slightly wider that the full width of the fabric;
7. Immediately roll another strip of fabric into the asphalt, lapping the earlier strip by at least 2 inches and pressing it into place as before;
8. Repeat steps 6 and 7 until the entire surface is covered; and
9. Mop the entire surface with a final coating of hot asphalt.

The three complete moppings of asphalt shall ensure that no fabric layer ever touches another fabric layer or the concrete surface. The Contractor shall examine all laps and ensure that they are thoroughly sealed down.

Each mopping shall cover completely, with a coat heavy enough to hide the fabric weave and all gray spots from the concrete. On horizontal surfaces, at least 12 gallons of asphalt shall be used for every 100 square feet of finished work. On vertical surfaces, at least 15 gallons per 100 square feet shall be used.

At the end of each day's work, all fabric that was laid shall have received its final mopping of asphalt.

Wherever the membrane ends or is punctured by drains, pipes, etc., the Contractor shall seal the area to prevent water from entering between the waterproofing and the concrete surface.

All flashing (at curbs, against girders, spandrel walls, etc.) shall be made of separate sheets that lap the main membrane by at least 12 inches. Flashing shall be sealed closely:

(1) with full metal flashing; or
(2) by imbedding its upper edges in a groove poured full of an acceptable joint cement.

At each expansion joint, the membrane shall not be broken but shall be folded to permit movement. At either end of the bridge, the membrane shall run well down abutments and shall allow for expansion and contraction.

6-08.3(4) PROTECTION COURSE

If the Drawings require, the Contractor shall place a layer of mortar at least 1 1/2 inches thick over the whole surface of the membrane just after it has cooled to air temperature. This layer shall be a mix of one part Portland cement to two parts sand. It shall be distributed evenly over the membrane, tamped gently into place, finished by hand to a smooth, hard surface, then covered and kept moist for one week.

6-08.4 MEASUREMENT

Bid items of work completed pursuant to the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs herein this Section.

Measurement for "Waterproofing" will be the number of square yards of the actual surface of the waterproofed area and will not include required overlap.

6-08.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-08 will be made at the Bid item prices Bid only for the Bid items listed or referenced as follows:

1. "**Waterproofing**", per square yard.

The Bid item price for "Waterproofing" shall include all costs for the work required to furnish and construct the waterproofing.

2. **Other payment information.**

Waterproofing of construction joints not shown on the Drawings shall be included in the Bid item price for "Waterproofing".

SECTION 6-09 CRIBBING

6-09.1 DESCRIPTION

Section 6-09 addresses the work of providing Materials and constructing cribbing as required by the Contract.

6-09.2 MATERIALS

Materials shall meet the requirements of Section 9-27.

6-09.3 CONSTRUCTION REQUIREMENTS

6-09.3(1) GENERAL REQUIREMENTS

6-09.3(1)A FOUNDATIONS

Before placing any gabion cribbing, the Contractor shall excavate the foundation or bed to the specified grade in accordance with Section 2-09.3(4). Foundation soils found to be unsuitable shall be removed and replaced in accordance with Section 2-09.3(1)C.

6-09.3(2) RESERVED

6-09.3(3) RESERVED

6-09.3(4) RESERVED

6-09.3(5) RESERVED

6-09.3(6) GABION CRIBBING

6-09.3(6)A DESCRIPTION

Gabions shall be constructed as indicated in the Contract.

6-09.3(6)B BASKETS

Baskets may be fabricated from either woven or welded steel wire; however, a gabion structure shall not include both. Baskets may be assembled with either lacing wire or clip fasteners; however, a perimeter or diaphragm edge shall not include both.

6-09.3(6)C DIMENSIONS

The Contractor shall supply gabion baskets in the lengths and heights the Drawings require. Each length shall be a whole number multiple (2 times, 3 times, and so on) of horizontal width. Horizontal width shall be 36 inches. All baskets from the same manufacturer shall be the same width and shall be within a tolerance of 5 percent of the manufacturer's stated sizes.

6-09.3(6)D FABRICATION OF BASKETS

Gabions shall be made so that the sides, ends, lid, and diaphragms can be assembled into rectangular baskets of the required sizes at the construction site. Common-wall construction may be used in gabion structures up to 12 feet high. Common-wall construction includes any basket where its top serves as the bottom of the one above it, or where one wall serves an adjacent basket. When gabion structures are more than 12 feet high, the baskets shall have independent sides, ends, top, and bottom.

Each gabion shall be divided by diaphragms into cells the same length as horizontal basket width. Diaphragms shall be made of the same mesh and gage as the basket body.

All perimeter and diaphragm edges shall be laced or clipped together so that joints are at least as strong as the body of the mesh itself. The ends of the lacing wire shall be anchored by three tight turns around the selvage wire.

6-09.3(6)E FILLING OF BASKETS

Stone shall be placed in such a manner as to meet the unit weight requirements of Section 6-09.3(6)F.

Filling shall be in compacted layers not more than 14 inches deep. If cross-connecting wires are required, the Contractor shall adjust the number and depth of layers so that wires occur between the compacted layers.

6-09.3(6)F UNIT WEIGHT REQUIREMENTS AND TEST

The unit weight of the filled gabion basket shall be at least 100 pounds per cubic foot. Should the unit weight be less than 100 pounds per cubic foot, the gabion will be rejected and the Engineer will require the Contractor to conduct and pass additional unit weight tests before completing other gabions.

The Contractor shall conduct either of the following unit weight tests to prove the density of completed gabions:

1. A filled gabion basket shall be selected from the completed structure and weighed; or
2. A gabion basket shall be filled with stone from a loaded truck that has been weighed. After filling, the truck and unused stone shall be weighed again. The difference between the two weighings shall be used to determine weight per cubic foot of the material in the gabion.

The Contractor shall conduct one unit weight test for each 500 cubic yards of gabions placed. The Engineer may reduce the specified frequency of these tests after proper unit weight has been consistently demonstrated.

In conducting unit weight test A or B, the Contractor shall provide and use scales that comply with Section 1-09.2.

6-09.3(6)G GABION CRIBBING CONSTRUCTION

Each row or tier of baskets shall be reasonably straight and shall conform with the alignment and grade indicated on the Drawings. Hexagonal mesh baskets shall be stretched endwise before filling. The stone shall be carefully placed in layers, then tamped or vibrated. The last layer shall fill each basket completely so that the secured lid rests upon the stone. Each basket shall be laced securely to all adjacent baskets and its lid then laced or clipped to the sides, ends, and diaphragms.

All selvage wires of ends of adjacent baskets shall be laced together. The bottom selvage of the basket being constructed on a previously constructed basket shall be laced to the top of that basket.

Excavation for gabions shall comply with the requirements for structure excavation in Section 2-09.

Backfilling behind or around gabions shall comply with Section 2-09.3(1)E.

6-09.4 MEASUREMENT

Bid items of work completed pursuant to the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs herein this Section.

Gabion cribbing will be the calculated by the cubic yard neat line volume of gabion baskets in place, using the manufacturer's stated dimensions.

Structure excavation will be measured by the cubic yard as specified in Section 2-09.4.

6-09.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-09 will be made at the Bid item prices Bid for the Bid items listed or referenced as follows:

1. "**Structure Excavation**", per cubic yard.

The Bid item price for "Structure Excavation" will be as specified in Section 2-09.5. All costs for special corners shall be included in the Bid item price per cubic yard for the adjacent bins measured as specified in Section 6-09.4.

2. "**Gabion Cribbing**", per cubic yard.

The Bid item price for "Gabion Cribbing" shall include all costs for the work required to furnish and install the gabion cribbing as specified.

SECTION 6-10 CONCRETE BARRIER

6-10.1 DESCRIPTION

Section 6-10 addresses the work of building precast or cast-in-place cement concrete barriers as required by the Contract.

6-10.2 MATERIALS

Materials shall meet the requirements of the following sections:

Portland Cement	9-01
Aggregates	9-03
Premolded Joint Fillers	9-04.1
Reinforcing Steel	9-07

Wire rope shall be Class 6 x 19, made of improved plow steel that has been galvanized and performed. Galvanizing shall meet ASTM A 603. The wire rope shall have right regular lay and a fiber core. It shall be 5/8 inch in diameter and have a minimum breaking strength of 15 tons.

All hardware (connecting pins, drift pins, nuts, washers, etc.) shall be galvanized in keeping with AASHTO M 232.

Connecting pins shall comply with ASTM A 449 and after galvanizing shall be checked for embrittlement in accordance with ASTM A 143. All other hardware shall comply with ASTM A 307.

6-10.3 CONSTRUCTION REQUIREMENTS

6-10.3(1) PRECAST CONCRETE BARRIER

The concrete in precast barrier shall reach a compressive strength of at least 4,000 psi at 28 days. No concrete barrier shall be shipped until test cylinders made of the same concrete and cured under the same conditions show the concrete has reached this strength. Class 4000 concrete that complies with Section 6-02 will meet this strength requirement. The Contractor may, however, alter the mix and aggregate grading if:

1. The Contractor indicates the substitution in accordance with Section 1-05.3(5);
2. The altered mix meets the requirement of a Contractor-provided mix design; and
3. No aggregate is used that is larger than the maximum for Class 4000 concrete.

The Contractor may use Type III Portland cement at no additional cost to the Owner.

Precast barrier shall be cast in steel forms. After release, the barrier shall be finished to an even, smooth, dense surface, free from any rock pockets or holes larger than 1/4 inch across. Toweling shall remove all projecting concrete from the bearing surface.

Precast concrete barrier shall be cured in accordance with Section 6-02.3(25)E except that the barrier shall be cured in the forms until a rebound number test, or test cylinders which have been cured under the same conditions as the barrier, indicate that the concrete has reached a compressive strength of at least 2,500 psi. No additional curing is required once the barrier is removed from the forms.

All barrier shall be the same length, except end sections and variable length units needed for closure. All barrier shall be new and unused. The manufacturer shall be responsible for any damage or distortion that results from manufacturing.

Only one section less than 10 feet long may be used in any single run of precast barrier, and it shall be at least 8 feet long. It may be precast or cast-in-place. Hardware identical to that used with other sections shall interlock such a section with adjacent precast sections.

When the barrier is being built next to roadway lanes open to traffic, a terminal section shall be connected temporarily to the end of the barrier built each day.

6-10.3(2) CAST-IN-PLACE CONCRETE BARRIER

Forms for cast-in-place barrier shall be made of steel or of exterior plywood coated with plastic. At the Contractor's option, the barrier may be constructed by the slip-form method.

The barrier shall be made of Class 4000 concrete that meets the requirements of Section 6-02. The Contractor may use Portland cement Type III and shall be at no additional cost to the Owner.

Immediately after removing the forms, the Contractor shall complete any finishing work needed to produce a uniformly smooth, dense surface. The surface shall have no rock pockets and no holes larger than 1/4 inch across. The barrier shall be cured in accordance with the requirements described in Section 6-02.3(11)B.

The maximum allowable deviation from a 10-foot straightedge held longitudinally on all surfaces shall be 1/4 inch.

The Contractor may build cast-in-place concrete barrier by the slip-form method. Concrete for slip-form barrier shall meet the requirements for concrete Class 4000 as outlined in Section 6-02, except that the fine aggregate gradation may be Class 1 or Class 2. Slip-form barrier shall be finished and cured as specified in Section 6-02.3(11)B.

At least 3 Working Days in advance of delivery to the Project Site, the Contractor shall request the Engineer to verify the concrete barrier to be free from stains, smears, and any discoloration.

6-10.3(3) RESETTING CONCRETE BARRIER

The Contractor shall reset concrete barrier as indicated in the Contract. If resetting is impossible immediately after removal, the Contractor shall store the barrier at locations approved by the Engineer.

6-10.3(4) JOINING PRECAST CONCRETE BARRIER TO CAST-IN-PLACE BARRIER

The Contractor may join segments of cast-in-place barrier to precast barrier where transitions, split barriers, or gaps shorter than 10 feet require it. At each joint of this type, the cast-in-place segment shall include hardware that ties both its ends to abutting precast sections.

6-10.3(5) TEMPORARY CONCRETE BARRIER

For temporary concrete barrier, the Contractor may use new or used precast barrier that complies with WSDOT Standard Plan requirements and cross-sectional dimensions, except that:

(1) it may be made in other lengths than those shown in the WSDOT Standard Plan; and
(2) it may have permanent lifting holes no larger than 4 inches in diameter or lifting loops.

The word "temporary" shall be visibly stamped or stencil painted on each barrier segment.

All barrier shall be in good condition, without cracks, chips, spalls, dirt, or traffic marks. If any barrier segment is damaged during or after placement, the Contractor, at no additional cost to the Owner, shall immediately repair the damage to a condition acceptable to the Engineer, or replace it with an undamaged section.

Temporary barrier no longer needed shall be removed from the Project. Site.

6-10.3(6) PLACING CONCRETE BARRIER

Precast concrete barrier shall rest on a paved foundation shaped to a uniform grade and section. The foundation surface shall meet this test for uniformity:

> When a 10-foot straightedge is placed on the surface parallel to the centerline for the barrier, the surface shall not vary more than 1/4 inch from the lower edge of the straightedge. If deviations exceed 1/4 inch, the Contractor shall correct them as required in Section 5-04.3(12).

The Contractor shall align the joints of precast segments so that they offset no more than 1/4 inch transversely and no more than 3/4 inch vertically. Grouting is not permitted. If foundation grade and section are acceptable, the Engineer may permit the Contractor to obtain vertical alignment of the barrier by shimming. Shimming shall be done with a polystyrene, foam pad (12 by 24 inches) under the end 12 inches of bearing surface.

Precast barrier shall be handled and placed with equipment that does not damage or disfigure it.

6-10.4 MEASUREMENT

Bid items of work completed pursuant to the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs herein this Section.

Precast concrete barrier will be measured by the linear foot along its completed line and slope.

Temporary concrete barrier will be measured by the linear foot along the completed line and slope of the barrier, one time only for each setup of barrier protected area. Any intermediate moving or resetting will not be measured.

Cast-in-place concrete barrier will be measured by the linear foot along its completed line unless the Contract specifies measurement per cubic yard for concrete Class 4000 and per pound for steel reinforcing bar per Section 6-02.4.

Cast-in-place concrete barrier light standard section will be by the unit for each light standard section installed.

6-10.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-10 will be made at the Bid item prices Bid only for the Bid items listed or referenced as follows;

1. "**Precast Concrete Barrier Type ____**", per linear foot.
2. "**Cast-In-Place Concrete Barrier**", per linear foot.
3. "**Concrete Class (Strength)**", per cubic yard.
4. "**Steel Reinforcing Bar**", per pound.

The Bid item prices for "Precast Concrete Barrier Type ____" and for "Cast-In-Place Concrete Barrier" shall include all costs for the work required for excavation, forms, placement, special construction features, and all other materials, tools, equipment, and labor necessary to complete the work as specified; except that when the Contract specifies, the Bid item price per cubic yard for "Concrete Class (Strength)" and the per pound Bid item price for "Steel Reinforcing Bar" shall be full pay for excavation, forms, placement, special construction features, and all other materials, tools, equipment, and labor necessary to complete the work as specified.

5. "**Cast-In-Place Concrete Barrier Light Standard Section**", per each.
6. "**Temporary Concrete Barrier**", per linear foot.

The Bid item prices for "Cast-In-Place Concrete Barrier Light Standard Section" and for "Temporary Concrete Barrier" shall include all costs for the work required to furnish, install, connect, anchor, maintain, temporary storage, and final removal of the temporary barrier. Contractor furnished barrier shall remain the property of the Contractor.

Payment for transition sections between different types of barrier shall be made at the Bid item price for the type of barrier indicated on the Drawings for each transition section.

SECTION 6-11 PRECAST CONCRETE RETAINING WALL STEMS

6-11.1 DESCRIPTION

Section 6-11 addresses the work of constructing WSDOT Standard Plan Reinforced Concrete Retaining Walls Type 1, 2, 3, and 4 using precast concrete wall stems.

6-11.1(1) RETAINING WALL SUBMITTALS

Before proceeding with construction of the retaining walls using precast concrete wall stems, the Contractor shall submit the following to the Engineer in accordance with Section 6-02.3(16):

1. Shop Drawings for fabrication of the wall stems, showing dimensions, reinforcing steel, joint and joint filler details, lifting devices with the manufacturer's recommended safe working capacity, and material specifications;
2. Shop Drawings for the erection of the wall stems showing falsework dimensions, support points, support footing sizes, erection blockouts, member sizes, connections, and material specifications; and
3. Calculations for the precast wall, the connection between the precast wall and the cast-in-place footing, and any modifications to the cast-in-place footing.

Calculations shall be by a professional civil engineer licensed in the State of Washington (see Section 1-05.3(12)).

6-11.2 MATERIALS

Concrete for the precast concrete wall stems and for the cast-in-place footing shall meet all the requirements for concrete Class 4000 as stated in Section 6-02.3. A water reducing admixture meeting the requirements of Section 9-23.6 shall be used for the cast-in-place footing.

6-11.3 CONSTRUCTION REQUIREMENTS

The precast concrete wall stems shall be fabricated in accordance with the dimensions and details shown on the Drawings, except as modified in the approved Shop Drawings.

The precast concrete wall stems may be fabricated full height in 8, 16, or 24 foot widths and with a mating shear key between adjacent panels. The shear key shall have beveled corners and shall be 1 1/2 inches in thickness.

The width of the shear key shall be 3 1/2 inches minimum and 5 1/2 inches maximum.

The shear key shall be continuous and shall be of uniform width over the entire height of the wall stem. Rolled on textured finishes shall not be used. Precast stem walls shall be cast in a vertical position if the Drawings call for a form liner texture on both sides of the stem wall.

The precast wall panel shall be rigidly held in place during placement and curing of the footing concrete.

To ensure an even flow of concrete under and against the base of the wall, a form shall be placed parallel to the wall stem, above the footing, to allow a minimum 1-foot head to develop in the concrete during concrete placement.

The reinforcing steel shall be shifted to clear the erection blockouts in the wall stem by 1-1/2 inches minimum.

All panel joints shall be constructed with joint filler installed on the rear (backfill) side of the wall. The joint filler material shall extend from 2 feet below the final ground level in front of the wall to the top of the wall. The joint filler shall be an inorganic flexible material and shall be installed to create a waterproof seal at panel joints.

The soil bearing pressure beneath the falsework supports for the wall stems shall not exceed the maximum design soil pressure shown on the Drawings for the retaining wall. The wall stem shall be placed a minimum of 1 inch into the footing to provide a shear key. The base of the stem shall be sloped 1/2 inch per foot to facilitate proper concrete placement.

6-11.3(1) TOLERANCES

The construction tolerances for the precast retaining wall stems shall be:

Height	±1/4 inch
Width	±1/4 inch
Thickness	+ 1/4 inch to - 1/8 inch
Conc. cover for steel reinforcing bar	– 1/8 inch to + 3/8 inch
Width of panel joints	± 1/4 inch
Offset of panels [1]	± 1/4 inch

NOTE [1]deviation from a straight line extending 5 feet on each side of panel joint.

6-11.4 MEASUREMENT

Measurement of the materials involved in constructing the precast concrete retaining wall stems and cast-in-place footing will be in accordance with Section 6-02.4 for the applicable related Bid items of Work involved in constructing WSDOT Standard Plan Reinforced Concrete Retaining Walls Type 1, 2, 3, and 4.

6-11.5 PAYMENT

All costs associated with constructing the retaining walls using precast concrete retaining wall stems shall be included in the Bid item prices for the applicable related Bid items of Work required for construction of WSDOT Standard Plan Reinforced Concrete Retaining Walls Type 1, 2, 3, and 4.